MAR 11 1942

Heating Piping & Air Conditioning

DESIGN
INSTALLATION
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MAINTENANCE

MARCH ★ 1942

INDUSTRIAL
COMMERCIAL
AND LARGE
BUILDINGS

ge 179—Journal Section, American Society of Heating and Ventilating Engineers

Heating and air conditioning services in wartime are described this month. This army laboratory is an example

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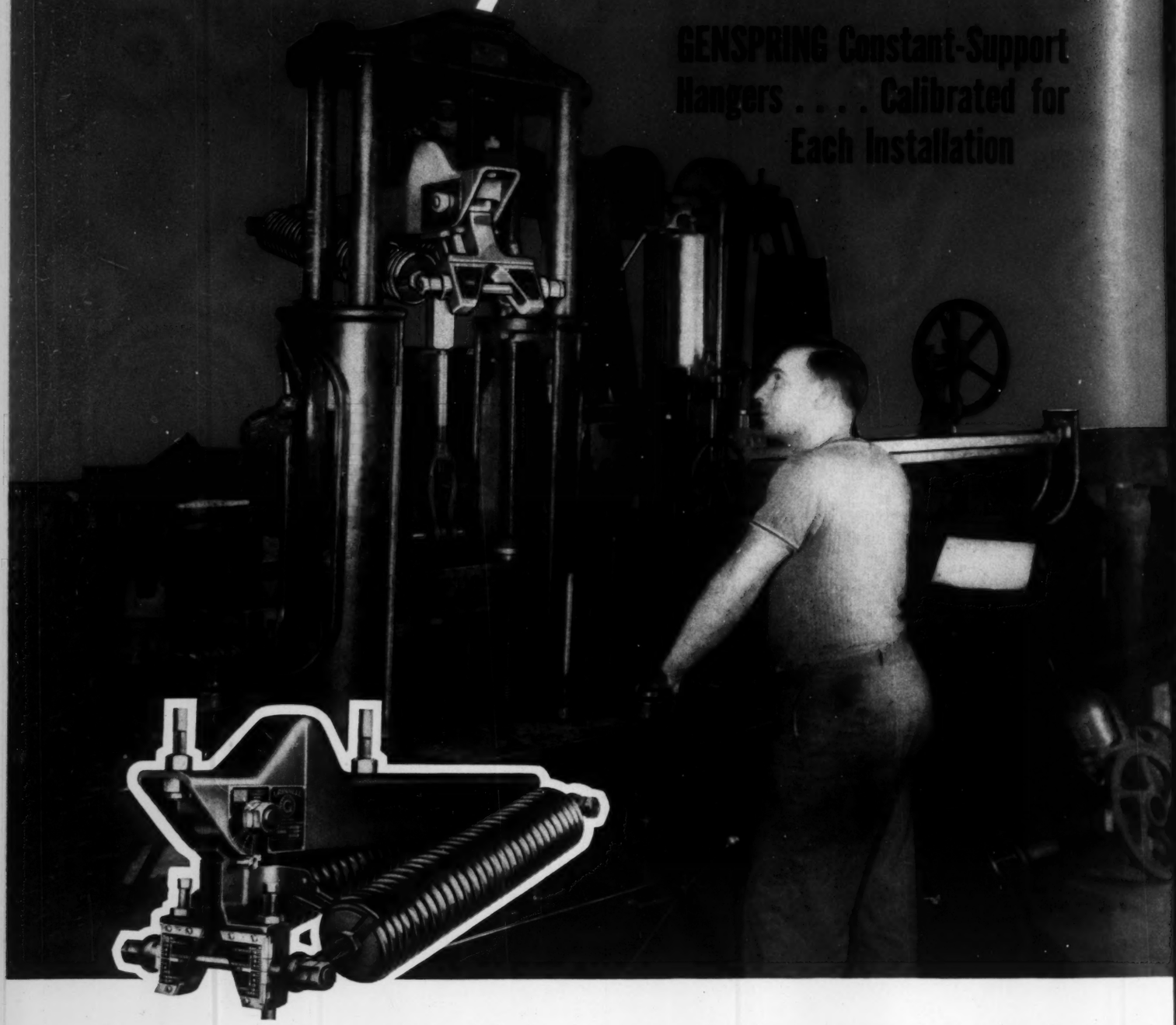
"Floating" PIPE-SUSPENSION

GENSPRING Constant-Support Hangers . . . . Calibrated for Each Installation



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Published monthly by the Keeney Publishing Co., 6 N. Michigan Ave., Chicago. Telephone: State 6916/ Subscriptions: U. S. and possessions, Canada, Mexico, Central America, South America, $2.00 per year; other, $4.00. Current copies, U. S. and possessions, 25c each, back copies 50c each. January, 1942, issue, $1.00 per copy/ Member of Audit Bureau of Circulations and the Associated Business Papers, Inc./

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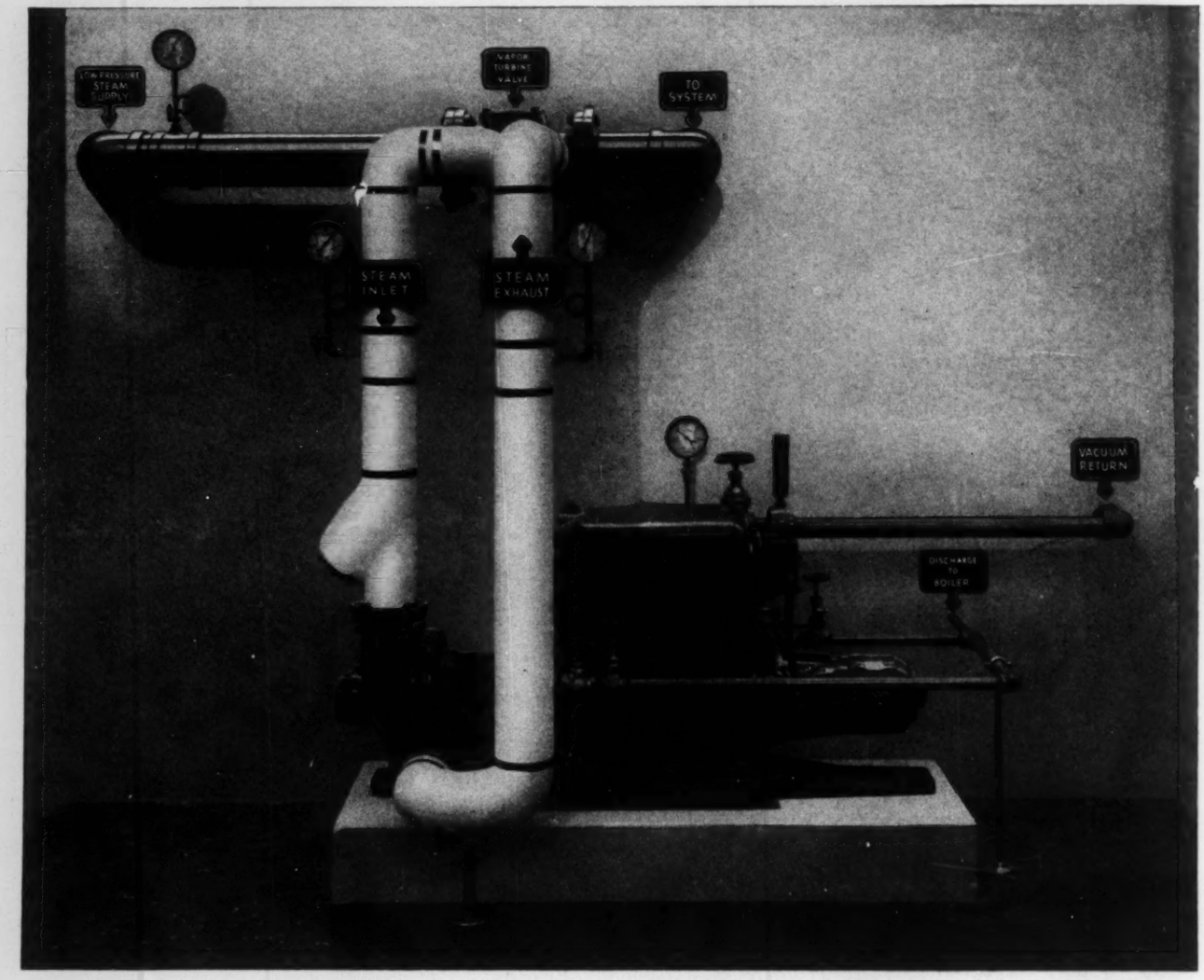
Interrupted Electric Service will not stop this NASH Heating Pump!



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This is because the prime motive power of this economical pump is a special steam turbine, controlled by a unique "Vapor Turbine Valve", which automatically bypasses from the heating main a small portion of steam, the exact amount necessary to develop the power needed to remove the condensate and maintain the required vacuum on the system. Even this small amount is passed immediately back to the mains, and goes on to the system with little heat loss. This pump operates on any system, high or low pressure.

The Vapor Turbine is a most economical pump, for the elimination of electric current does away with current cost, the largest single item in the operation of an ordinary return line heating pump. Bulletin on request.

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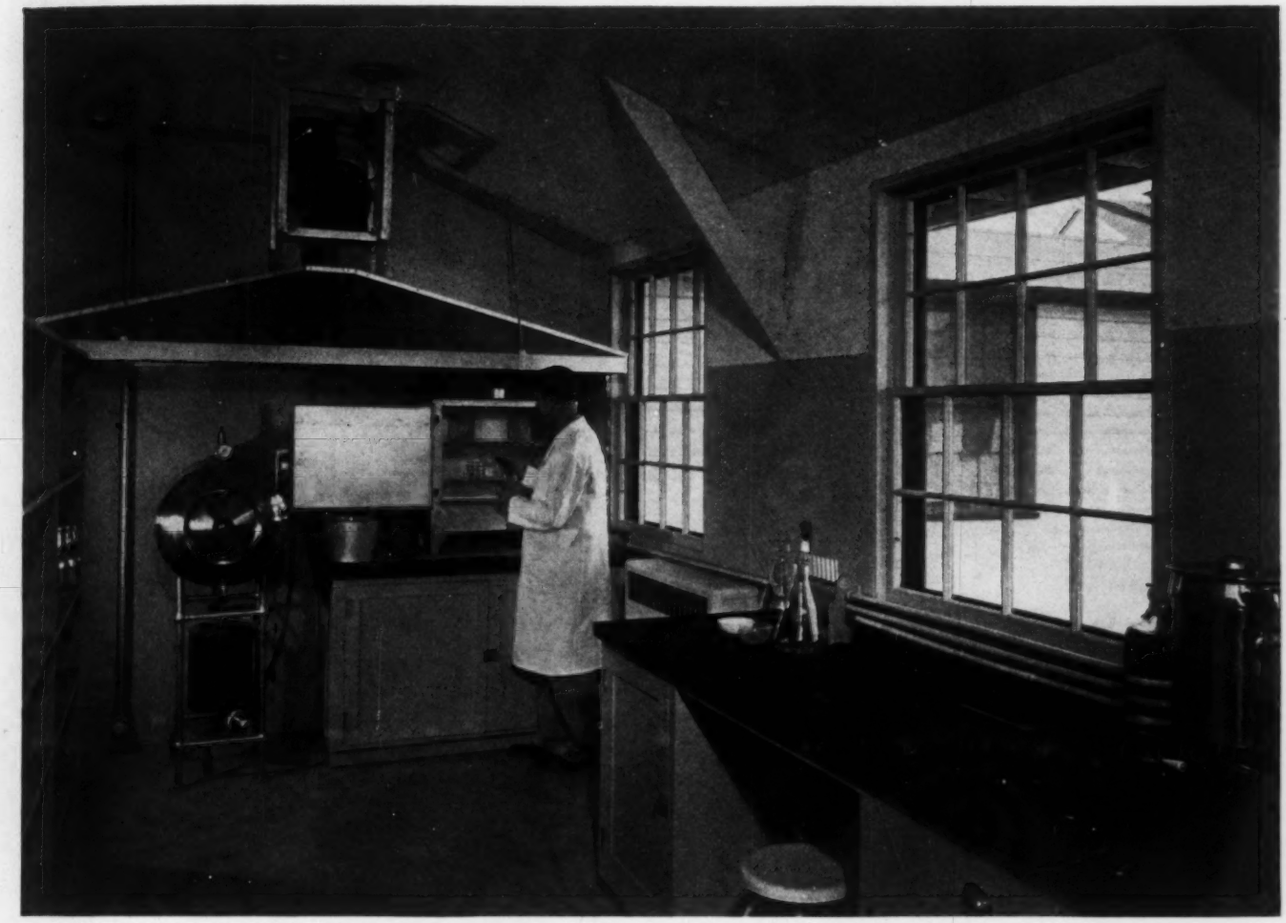


At this army laboratory, the outlet grille of the convector is cut into the workbench, putting both under the window where they belong

Wide Variety of Standard Heating and Air Conditioning Equipment in War Use

Fred Pederson Pictures Many Applications

SUMMARY—Army posts and naval stations throughout the country reveal an astonishing variety of interesting applications of standard heating, cooling and air conditioning equipment contributing to our war effort. There is practically a limitless need on the part of our armed forces for heating and air conditioning equipment to solve both process and comfort problems, as indicated by this brief review prepared by Mr. Pederson, of the Trane Co. . . . Applications of the type described represent the combined recommendations of army and navy engineers, as well as the civilian consulting engineers, architects, and heating and air conditioning contractors also engaged in "construction for victory"

AN examination of army posts and naval stations throughout the country reveals an astonishing array of interesting applications of standard heating, cooling and air conditioning equipment which conclusively substantiate the wartime value of these products and which unquestionably have assisted materially the advancement of engineering practice in this field.

Standard unit air conditioners are used to maintain the proper conditions for ammunition storage and bullet filling rooms at an arsenal, for the tropical test rooms at an army base, for the bomb rooms at a naval air station, for the chemical warfare division at another arsenal, for the photographic laboratory at an army air field, for the motor testing rooms at another naval air station and for the fuse loading rooms at a large navy yard. Conventional cooling coils are installed in the wind tunnel at an army air field. Regular heating coils are serving such timely functions as the mothproofing rooms at an army camp and the parachute drying towers at a large air training school. Ceiling mounted projection type unit heaters take care of the

glue processing rooms at a navy station.

The applications mentioned above, of course, are process uses of this equipment—uses in which the temperature and humidity conditions provided by the equipment serve a specific process or operation and render it more uniform, safe, efficient or exact. Since many of these are of a precise nature, it is noteworthy that standard equipment was selected to do the job. A few years ago many of these applications were unheard of while today they are commonplace.

Of course, the more conventional applications of heating, cooling and air conditioning equipment in military projects are the greater in number by far and are counterparts of similar applications in non-military buildings. Let's take a peek at a naval air station, where unit air conditioners, projection and propeller type unit heaters, convectors, unit ventilators and steam heating specialties all are represented in such buildings as workshops, barracks, hangars, garages, and officers' and enlisted men's quarters.

Unit air conditioners are used to provide the officers' quarters with winter air conditioning in the form of correctly heated and humidified air. The units are suspended from the ceiling in the basement. The heating medium is steam, and it is controlled by motorized steam valves which operate under the command of a room thermostat. Humidity control is included also. The heated and cleansed air is carried to the various rooms through duct work. Switches are provided for the operation of the fans in the units during the summer for the circulation of outside air, return air or a mixture of both—as desired by the occupant. A desirable flexibility is afforded by this arrangement, and in this way—with individual units—there is no danger of distributing cooking odors, etc., to other quarters. The units which serve the quarters for the enlisted men are similarly arranged and perform the same identical functions. However, in this case, they are installed in small recesses in the garage. All units are easily accessible for oiling, removing filters, etc.

In one of the important workshops the desired conditions are maintained by a unit ventilator complete with face and bypass dampers.

The operations in this workshop are of a precise nature and therefore the new type of electrostatic air filter is used to protect accurately machined parts from floating dust particles.

Conventional unit heaters—both projection and propeller types—are found throughout a station of this sort in a variety of buildings.

In August, 1940, when a sudden spurt in enlistments first began to tax the facilities of the permanent physical plant at a naval training station, navy engineers decided to convert two idle airplane hangars into housing units. Within four weeks these 100 by 500 ft hangars had been transformed into living quarters for 1560 men. Unit heaters, suspended from the 18 ft ceilings of these framed buildings, provided a most satisfactory solution to the problem of diffusing heat through the giant structures. The converted hangars, which are without partitions of any sort, house 780 men each. A short while later other propeller type unit heaters were similarly applied in a drill hall built to the same specifications.

Other buildings at this station, which are likewise equipped, include the station laundry, service school, mess hall and swimming pool.

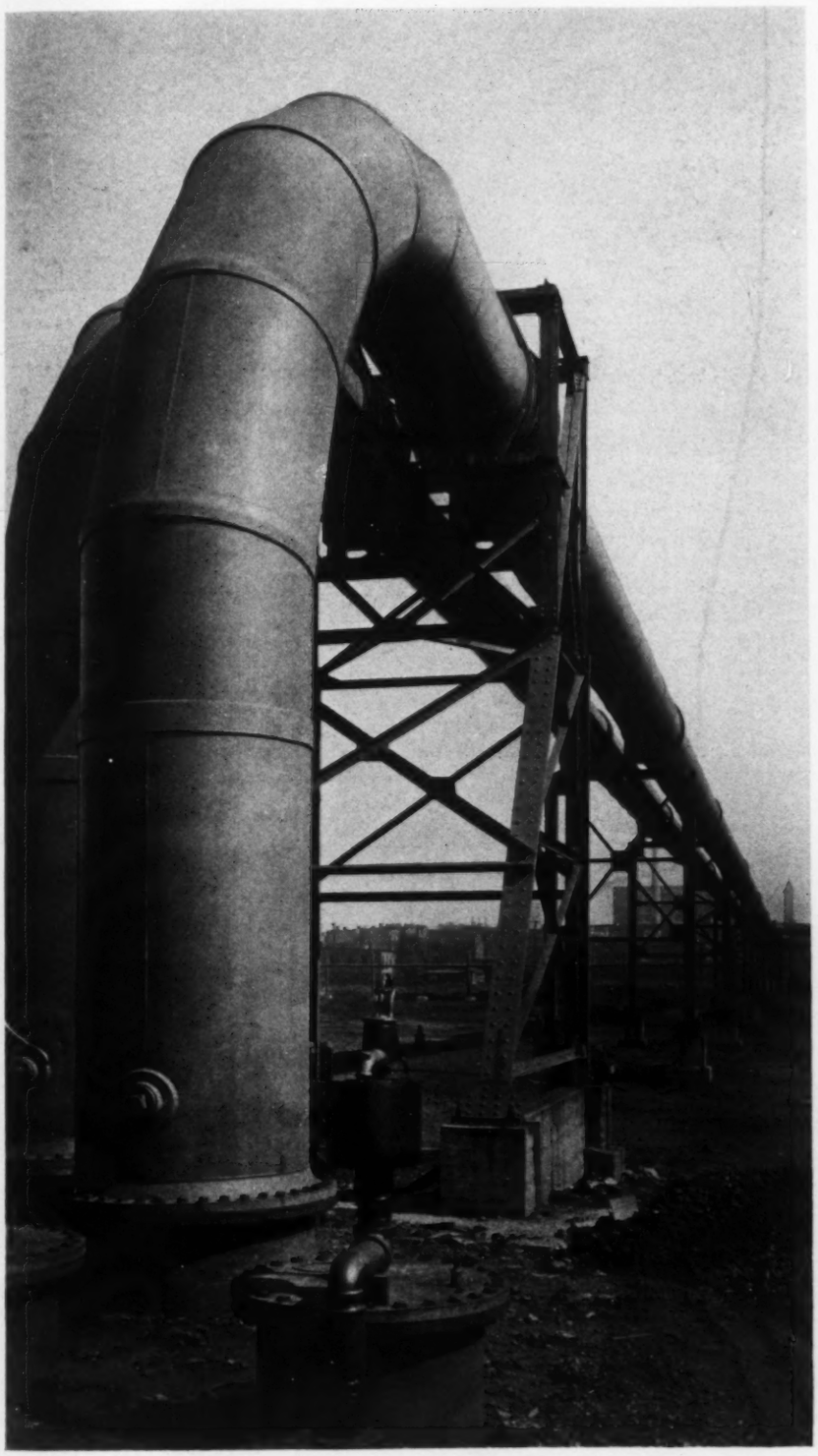
The limited space available and the necessity for cleanliness were factors which influenced the selection of heating units for a new army corps area laboratory. As an accompanying illustration shows, the discharge grille of one of the convectors is cut into the laboratory work table immediately above. In this way, maximum space conservation is achieved and both the heating unit and the workbench can be right by the window where they belong.

Typical of practical army camp construction are the buildings of the general hospital at one of the army forts. Here sloping top convectors operate on a vacuum heating system with high pressure steam supplied from a central boiler plant. The steam is introduced into each building from underground mains. There are high pressure bucket traps and strainers on the steam lines. The advantages of a sloping top on a hospital room heating unit are emphasized by the fact that no object can be placed on top of the cabinet to collect dust and dirt—and the absence of legs renders it easy to clean under the unit.

Sloping top convectors in this army camp hospital promote cleanliness

CODE FOR PRESSURE PIPING

Section 2 on Gas and Air Piping and Section 3 on Oil Piping Systems Reviewed by Subcommittee Chairmen



SUMMARY—Since the ASA code for pressure piping was first issued as a tentative standard in 1935, there have been many developments and advances in piping practices, as described by Sabin Crocker in the January HPAC in the first of a group of articles, of which this is the third. The piping code has been thoroughly revised and is being reissued as a full American standard. Section 1 of the new code, on power piping, was reviewed by Alfred Iddles last month. This month, the section on gas and air piping is covered by John S. Haug, chairman of the subcommittee on gas and air piping systems and consulting engineer for the United Engineers & Constructors, Inc., and the section on oil piping systems is analyzed by A. D. Sanderson, chairman of the subcommittee on oil piping systems and engineer with the Standard Oil Development Co. . . . The next of these articles on the new code for pressure piping is to cover changes involving district heating piping systems, and the section on refrigeration piping

SECTION 2 of the American Standards Association code for pressure piping (B31) covers piping for air at pressures above 30 psi (gage) and for fuel gas, illuminating gas and other substantially non-corrosive gases. The provision covering non-corrosive gases is an extension of the scope to permit other gases than air and fuel gas to qualify under the code. Certain exceptions are made to the scope of the code, such as connections which are a part of apparatus, firebrick-lined pipe for hot gas, refinery process gas in refineries, sewer gas, waste gas and ventilation ducts. Oil well and natural gas well piping, and also piping for natural gas field gathering systems, are excluded when outside villages or towns. Residential and commercial building gas piping is excluded from this code.

The piping systems in this section are grouped into two divisions. Division 1 covers piping in more or less populous districts, and division 2 covers cross country transportation systems which traverse open or

Gas holder connections in an eastern manufactured gas plant

sparsely populated country. In division 1, the scope has been extended to mines. In the case of cities or villages, the scope of division 1 has been confined to the populated areas. Piping in territory which is sparsely populated or rural in nature, even though within legal city boundaries, which sometimes extend for miles into the country, is relegated to division 2.

Pipe Wall Thickness and Working Pressure—One of the principal changes in the new code as compared to the previous edition is the extension, revision and enlargement of the table giving the allowable S values for use in the formula upon which pipe wall thickness is based for piping in division 1. In this section the S values, representing allowable stress due to internal pressure, are based upon 60 per cent of the yield strength of the material for temperatures less than 100 F and 52 per cent for temperatures up to 450 F, which is the maximum temperature covered by this section. These values have been reduced for pipe having a longitudinal seam in accordance with efficiencies considered characteristic of the types of joints resulting from the various methods of manufacture. These efficiencies are also referred to in footnotes, one of which contains numerical values assigned to the types of welds.

The list of material specifications has also been considerably enlarged and revised. It is recognized that in any case materials will frequently be used differing to a greater or less degree from those listed. The revised code now provides that S values for pipe not listed may be $0.6K$ for temperatures up to 100 F, where K is the effective yield strength. The effective yield strength may be determined by actual test of material or may be taken as the yield strength of the material multiplied by the efficiency of the longitudinal joint, if any.

With certain steels having extremely high yield strengths, an S value of $0.6K$ might give too low a safety factor in relation to the ultimate strength. It is therefore provided that the value of yield strength taken to determine the S value may not exceed 80 per cent of the ultimate tensile strength. The listed specifications contain certain elongation and other minimum requirements, and these also would prevent the use of material which was too brittle having a yield strength too close to the ultimate tensile strength.

A natural gas distributing manifold and control station at a midwestern gas company Photo courtesy Gas Age

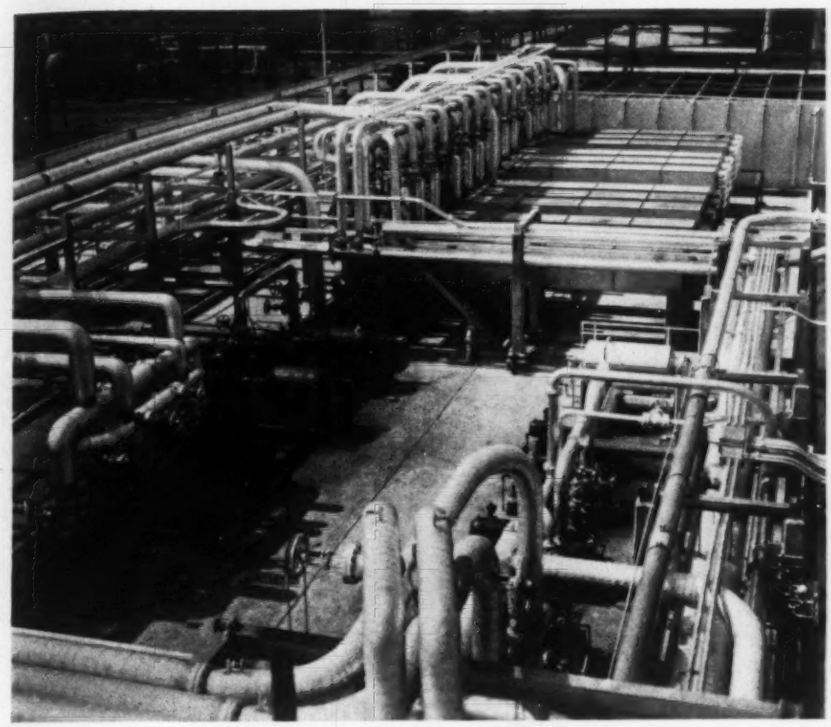
The formula for determining pipe wall thickness contains a C factor to be added to the thickness necessary to resist pressure alone. This factor is an allowance for threading, mechanical strength and/or corrosion. It has been pointed out that for mechanical strength it should not be necessary to add the same thickness of high strength material as of low strength material. Also, there are certain uses of steel pipe for gas where corrosion is negligible. For plain end steel pipe, therefore, the C factor has been "rationalized" by a formula dividing it into two parts; one part, for mechanical strength, is an inverse function of the yield strength, and the other is for possible corrosion and may be omitted where service is definitely non-corrosive. However, it is provided that where the piping is definitely subject to corrosion, adequate provision must be made to insure that the pipe is not rendered unsafe by corrosion.

For division 1, the piping thickness formula may be used to determine allowable working pressure of existing pipe, using the actual diameter and actual minimum thickness in the formula.

For piping in division 2, the maximum working pressure for pipe other than cast iron is based on the mill test of the pipe and may be taken as 80 per cent of the test pressure. For cast iron pipe, the allowable working pressure is determined by a formula based on pipe wall thickness and allowable stress.

Fittings — The paragraphs on standard and special fittings have been entirely rewritten to bring them up to date and conform with current practice.

A provision has been made for low pressure special fittings which permits the fittings to be less in strength than the pipe when the maximum working pressure in the line is less than the minimum design pressure for the adjoining pipe, i.e., 180 psi for pipe up to 24 in. and 100 psi for pipe greater than 24 in. These minimum design pressures are to ensure against the use of extremely thin pipe which might be too weak to withstand handling and mechanical loads. It is provided that such special fittings must not be less in thickness than the pipe and must be capable of withstanding an internal hydrostatic test of 1½ times the actual working pressure. For low pressure work therefore, the fittings will be amply strong mechanically without requiring the reinforcements



Typical oil piping—pump and exchanger manifold

necessary for high pressures, where the bursting strength of fittings matches that of the adjacent pipe.

Pressure Testing After Installation—A blanket provision for the complete piping system requires it to be capable of withstanding a test pressure after erection of: 150 per cent of the maximum service pressure for systems within the scope of division 1; and 50 psi more than the maximum service pressure for systems within the scope of division 2.

Bolting—The previous code required alloy steel bolting for division 1 piping when pressures were above 300 psi. The revised code allows high strength carbon steel bolts for pressures above 300 psi at ordinary temperatures and alloy steel bolts where pressures exceed 300 psi and temperatures also exceed ordinary atmospheric temperatures.

Pipe Joints—This section has also been rewritten and several paragraphs on joints for non-ferrous pipe have been added which cover socket brazed and soldered joints within their limitations; also flared and compression tubing joints have been covered. This supplements the more usual types of welded, flanged and expanded joints, as well as threaded and gland packed joints.

—The pressure limitation in bell and spigot caulked joints has been raised to allow this type of joint to be used up to 100 psi.

Tables—The tables of specific requirements for various pressures have been revised to increase their usefulness, and a supplementary table has been added to cover pressures above 800 psi. Where American standards for fittings are not available, manufacturers' standards are permitted. Such fittings must be capable of withstanding a hydrostatic pressure of 1½ times the pressure for which the manufacturer guarantees them.

The revised code has been the subject of much study and consultation by a committee in which were representatives of the manufactured gas, natural gas, compressed air, mining and bottled gas industries. It is hoped that this latest revision will be found useful to those industries.

Oil Piping Systems

Piping requirements and specifications under section 3 of the code are understood to apply particularly to oil piping, refinery gas piping and piping for gasoline recovery plants. However, it is intended that these requirements and specifications may also be applied for the corresponding pressure and temperature conditions to all piping other than oil, such as steam, air, water, gas, etc., used in the distribution systems and process areas of plants devoted principally to the processing and handling of oils, even though some of such piping may be covered by other sections of the code.

The requirements are not intended to apply, however, to steam piping within the limits of the boiler house or boiler plant areas of such plants, nor for boiler feedwater piping between feed pumps and boilers. Piping for these services and in these locations shall conform to the requirements of section 1.

It is the intent that miscellaneous piping as covered by other sections of the code, such as refrigerating piping, shall conform to the piping requirements of the individual sections concerned insofar as practicable, but with the provision that piping as covered by section 3, for oil piping, may be used when within refinery limits.

Cast Iron Pipe and Fittings—Several new requirements for cast iron pipe have been added and provisions existing in the previous edition of the code have been clarified to cover more fully the applications of cast iron pipe for oil service.

Paragraph 306 (1) has been expanded to read as follows:

Cast iron pipe may be used for:

1) Oil, refinery gas, brine, foamite, etc., for underground service where the temperature within the pipe is less than 300 F. No operating pressure limit is prescribed except as the pressure may be limited by the specified test pressure and by the requirements of the pipe wall thickness formula. Above ground, cast iron pipe may be used for oil or refinery gases for pressures not in excess of 150 psi, where the metal temperature does not exceed 300 F.

Pipe Joints—The types of joints formerly permitted for cast iron pipe above ground are now specified for use either above or below ground with the special proviso that pipe lines above ground having joints which are of the packed gland type shall be suitably anchored to prevent pulling the joints apart. These requirements, as contained in the new issue, are as follows:

All cast iron pipe shall have either bolted flange connections, threaded joints, sleeve or gland couplings, or gland

packed joints made integral with the pipe, or special joints such as rubber or flexible rings held tight by pressure and properly retained, or bell and spigot pipe connections.

When cast iron pipe is used above ground with joints of the packed gland type or other type offering no positive mechanical connection between the joined sections, the pipe shall be anchored in such a way as to prevent the joints pulling apart.

More liberal use of the various types of flange facings is contemplated in paragraph 318. The following types of flange facings may be used for all classes of piping, subject only to the temperature and pressure limitations given for plain facings and for the male and female facing: (1) Plain, or raised face with smooth or serrated finish, not to be used for temperatures in excess of 750 F. (2) Male and female, not to be used for pressures over 300 psi when temperatures exceed 900 F. (3) Tongue and groove. (4) Ring type. (5) Ground ball type.

Six tables have been included in the section containing pressure-temperature ratings for American standard cast and forged carbon and alloy steel valves, flanges and fittings, including pressure series from 150 to 2500 psi. Three of these tables concern the ring joint facings, whereas the remaining tables contain ratings for facings other than ring joints, all of which are given the same value. In other words, plain face, raised face, male and female, tongue and groove and the ground ball type facings are assigned the same pressure-temperature ratings, subject of course, to their limitations in use as given above. At present, welded joints are considered the equivalent of ring joints in the assignment of ratings.

To assist in determining pressure ratings for temperatures intermediate between those listed in the tables, six new charts have been included on which rating curves have been drawn representing the seven pressure series covered in the American standard for steel flanged fittings and companion flanges.

This issue of section 3 also contains extensive provisions regarding permissible types of joints for non-ferrous pipe and tubing which were not covered in the 1935 edition of the piping code. The new requirements are as follows:

For pressures and temperatures permitted by this code for the pipe or tubing, valves, fittings and flanges shall be attached to non-ferrous pipe or tubing by threading (when made to iron pipe size dimensions), by compression type, or flared, or flanged or lapped connections. Joints of the socket braze type also may be used for the attachment of valves, fittings and flanges to non-ferrous pipe and tubing. Such joints shall be made with brazing alloy consisting of not less than 60 per cent copper having a melting point above 1000 F. The brazed junction between pipe and valve, fittings or flange shall extend the full depth of the socket. Fillet brazed joints are not acceptable.

Since the allowance for mechanical strength and corrosion in figuring the minimum pipe wall thickness for non-ferrous pipe and tubing has been reduced to zero in all sections of the code, it was necessary to specify certain minimum wall thicknesses for plain end, non-ferrous pipe and tubing to avoid possible use of overly thin pipe which would not be suitable from the standpoint of mechanical strength. The requirement for minimum thickness of non-ferrous pipe and tubing is as follows:

For plain end non-ferrous pipe or tubing, minimum wall thickness shall be as follows: For nominal sizes up to ¾ in., the nominal thickness shall not be less than specified for type K of ASTM specification B88; for nominal sizes ¾ in. and larger, the nominal wall thickness shall not be less than 0.049 in. Additional wall thickness should be provided as required to care for corrosion, erosion or mechanical strength.

As has been mentioned in previous articles, an alternate formula based on the Lamé formula for computing wall thickness of pipe has been added to this section. The application in the oil section differs from that in the power section in that the alternate formula may be used irrespective of diameter and wall thickness, whereas for power piping its use is limited to nominal pipe sizes 4 in. or greater, and where the minimum thickness of the pipe is equal to or greater than 10 per cent of the inside diameter.

Allowable Stress Values — Each individual subcommittee of the sectional committee which formulated the code has selected values of allowable stress for computing pipe wall thickness according to its interpretation of the hazards involved and in relation to the material used. For oil piping within refinery limits, the allowable stress at a temperature of 650 F is based on a factor of safety of four as applied to the tensile strength, whereas for power piping, a factor of safety of five is used. At 650 F, for example, grade A, ASTM specification A106, material is assigned an allowable stress of 12,000 psi for oil piping, but only 9600 psi for power piping. Other values for the various materials differ correspondingly.

At higher service temperatures, where creep of the metal is a predominant factor, the difference in practice between power and oil piping is again evident. It is customary practice in power piping to base allowable stresses at elevated temperatures on 80 per cent of a creep strength which will result in a rate of elongation of 1 per cent per 100,000 hr; whereas in oil piping, a rate of 1 per cent per 100,000 hr is commonly used. This is reflected in the value of allowable stress of grade A, ASTM specification A106 material, which is assigned 7000 psi for oil piping, whereas for power piping, only 5600 psi is permitted.

Again, at lower service temperatures, this section of the code permits a greater increase in allowable stresses than is permitted by the power section, for instance. As explained in the January HPAC, the increase in allowable stresses at the reduced temperatures is based on increased yield strength of material as well as the reduced hazard involved in conveying the fluids at the lower temperature.

Extensive tables of new and revised allowable stresses have been included in this new issue of section 3 of the code to provide for many of the more commonly used pipe materials in the oil industry, including carbon and alloy steels, brass and copper, cast iron and wrought iron. New values of allowable stress applicable to oil piping systems used outside of refinery limits also have been included.

Tables of specific requirements follow the pressure-temperature divisions as classified in the 1935 edition of the code, but the contents have been revised and expanded to keep abreast of oil piping practice.

Panel Heating, Fluorescent Lighting Feature New Addition to High School

ERWIN L. WEBER, CONSULTING ENGINEER, GIVES DATA ON INSTALLATION EMPLOYING PIPE COILS IN CEILINGS

SUMMARY—The third addition to the Clover Park high school, near Tacoma, combines panel heating and indirect fluorescent lighting. A total of 13,000 lineal feet of pipe coils are placed in the concrete ceiling slabs or embedded in suspended ceilings. The coils—of welded construction, bent on 6 in. centers—receive water from a converter furnished with steam from a central boiler plant. There are five separate heating zones, the water for each being supplied by a thermostatically controlled, three way valve which mixes hot water and cooler return water. . . . Flow and return mains are run in the attic space to avoid constructing trenches under the first floor (there is no basement). The ceilings are divided into 8 ft by 26 ft bays by 14 in. deep concrete beams. There is a lighting trough on each side of the beams; the coils are embedded between the beams

THE third addition to the Clover Park high school, near Tacoma, Wash., combines panel heating and indirect fluorescent lighting. The building comprises offices, locker rooms, music rooms and the foyer to the future auditorium on the first floor, and a large library and chemistry, physics, dietetics and biological laboratories on the second floor.

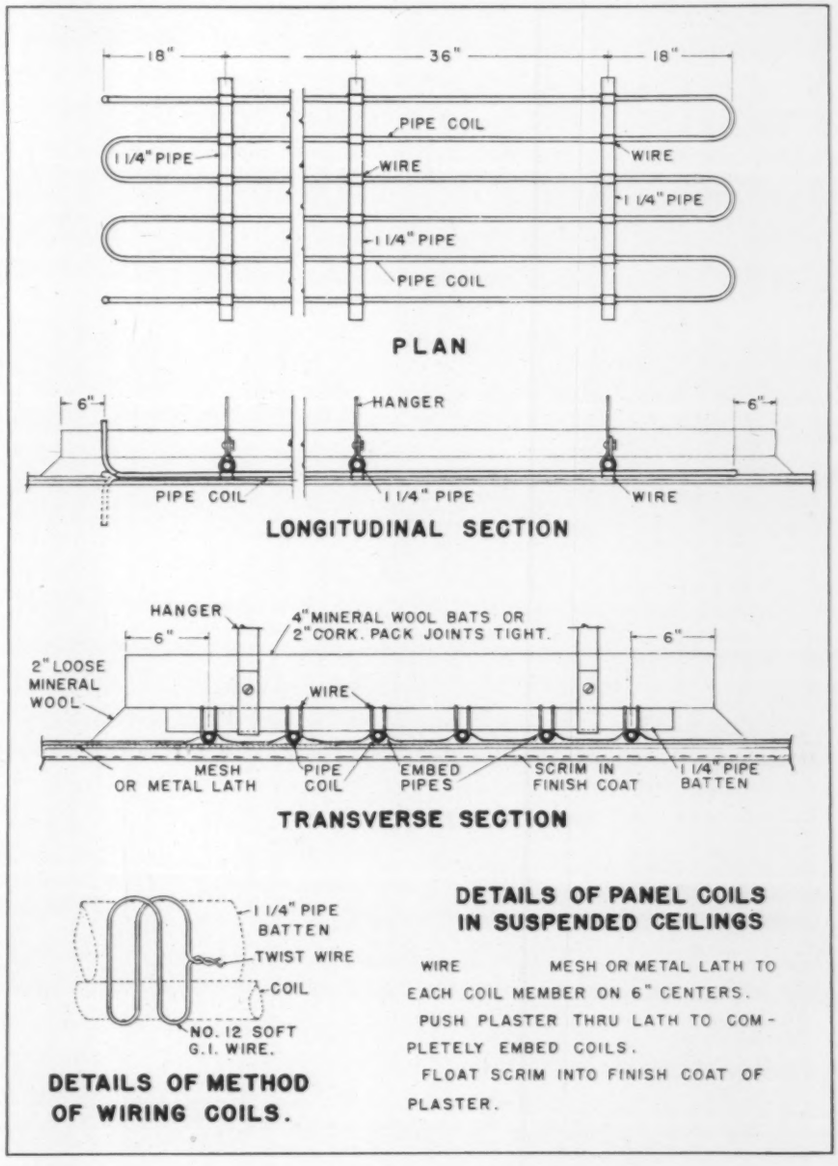
There is no basement. The first story has a concrete floor laid on the ground and is finished in rubber tile. The second story has concrete floor slabs and is finished in rubber tile and maple floors. The ceiling of the second story is a concrete slab, and there is a gable roof forming an attic space.

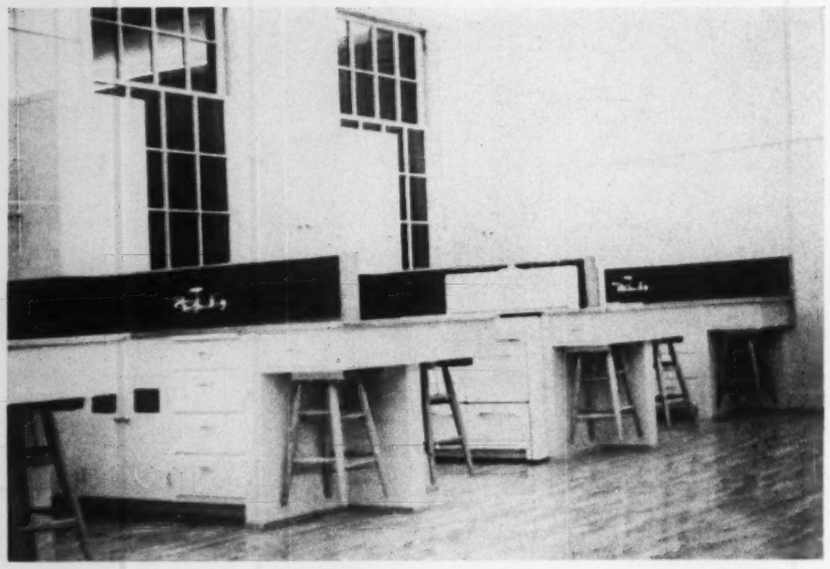
The water for the panel coils is heated in a converter with 40 sq ft of copper heating surface, by steam from the central boiler plant. The water is circulated by a centrifugal pump with a capacity of 140 gpm when operating against a head of 40 ft.

Five Zones

There are five separate heating zones—east rooms, west rooms, south rooms, library and music room. Each zone is supplied with flow water through a thermostatically controlled, three way, diaphragm mixing valve which derives hot water from the converter and mixes it with the cooler return water to supply each zone with water of the temperature demanded by its respective thermostat.

To avoid constructing underground trenches under the first floor, the flow and return mains are both run in the attic space. Branches from the flow main drop down to the flow valves in each room and supply the lines to the heating coils. Each coil is connected through an equalizing non-reflux elbow to the return main in the attic. This main pitches upward to the expansion tank to relieve air from the coils. The air is also relieved from other high points in the mains by auto-





This view of the dietetics laboratory was taken at night with no illumination other than that provided by the indirect fluorescent lighting system. It serves to show that spaces under tables, desks, etc., are not cold when ceiling heating panels are used, for the radiant heat rays are diffused and reflected like light rays

The question is often asked if the space under tables, desks, etc., is cold when ceiling panel heating coils are used. The view of the dietetics laboratory answers that question when we note how clearly the stools under the tables are seen and remember that radiant heat follows the same laws as light, and that the light reflecting value of floors is less than 50 per cent while the heat reflecting value runs well over 80 per cent. Hence there is a much greater re-direction of heat rays than of light rays, resulting in a very noticeable uniformity of temperature. The photograph was taken at night, with illumination provided entirely by the indirect fluorescent lighting system.

The building was designed by Charles V. and Clarence Rueger, architects. The electrical, mechanical and sanitary equipment were designed by the author. The heating and plumbing were installed by the Advance Plumbing & Heating Co. The panel heating system was licensed from Richard Crittall & Co., Ltd., through Wolff & Munier, Inc.

matic air relief traps. The equalizing non-reflux elbows were adjusted to give a uniform 15 F drop in temperature through each coil.

Coil Construction

The system comprises about 6000 lineal feet of ½ in., 5200 lineal feet of ¾ in., and 1800 lineal feet of 1 in. steel pipe. The coils are bent on 6 in. centers with all joints welded, and were tested to 500 psi air pressure under water. A steel ball was blown through each coil to insure against "inside welds" and other obstructions. About 70 per cent of the coils are in the concrete ceiling slabs and the balance are embedded in suspended ceilings.

The ceilings are divided into bays about 8 ft wide and 26 ft long by 14 in. deep concrete beams. An indirect fluorescent lighting trough is placed on each side of each beam and the heating coils are embedded in the concrete panels between the beams. The acoustical material is applied to the side walls above the blackboard space.

AIR CONDITIONS FOR PRECISION GAGES

The air conditions set up for the constant temperature room for the finishing of precision gage blocks at Pratt and Whitney's new plant were 68 F dry bulb and 50 per cent relative humidity, to be maintained the year around. These are the conditions which are used by the National Bureau of Standards.

The importance of exact control of the dry bulb temperature is easily recognized on account of the precision apparatus in use. The constant relative humidity of 50 per cent is necessary due to the use of the interferometer, which is dependent upon the velocity of light waves for its use, which velocity is affected by the relative humidity in the air.

The very exact conditions that were demanded recommended the use of an air washer, delivering air at a practically constant dew point, all the year around. Any change in room conditions due to infiltration of air at either a lower or higher dew point is compensated for by a room humidistat, varying to a slight degree the dew point of the delivered air at the washer.—*From an article by C. L. Roberts, chief engineer, Automatic Refrigerating Co., published in the Frick System.*

Oliver J. Prentice, of the C. A. Dunham Co., used the phrase below in the house organ he edits, and it was so enthusiastically received by his readers that wider dissemination seemed to be demanded. Mr. Prentice therefore had a quantity of blotters printed, and is distributing them to friends and enclosing them with his correspondence. Being a friend—a role much enjoyed, by the way—we got our hands on one, as well as permission to reprint it here for all readers of HPAC

Nothing matters right now but winning the war, because nothing will matter if we don't win it.

O. J. PRENTICE

"OPEN FOR DISCUSSION"

Communications to the Editor

SOLAR HEAT GAIN THROUGH FROSTED AND PLAIN GLASS

THE EDITOR—

I have been interested in the discussion regarding solar heat gain through glass which appeared in the September HPAC on p. 575 by Dr. Houghten and in the December HPAC, p. 753, by Mr. Avery.

The original question was: How does solar heat gain through frosted glass compare with that through plain glass? Mr. Avery confuses the issue when he introduces the question of absorption by the glass with the accompanying processes of conduction and reradiation; these may or may not have an effect on the net amount of solar heat transmitted through the glass to the interior.

This seems to be a case where test data are more convincing than theory. Such data are available. [See Surface Absorption of Heat From Solar Radiation, by Hechler and Queer. Refrigerating Engineering, February, 1933.] Briefly the test method was to compare the amount of solar heat transmitted by various materials to that transmitted by a reference material with black surfaces. The heat transmitted through the materials was measured with heat flow meters. Included in the tests were two comparable runs of present interest, one with clear glass and one with a piece of glass frosted (sandblasted) on the surface exposed to the sun and smooth on the other surface. Double strength window glass was used in both cases. The pertinent data are:

	Reference Panel	Clear Glass	Frosted Glass
Air temperature, average, F	86.3	86.3	...
	83.1	...	83.1
Wind velocity, average, mph	15.2	15.2	...
	5.9	...	5.9
Surface temperature, average, F	116.7	87.9	...
	121.0	...	94.3
Heat flow, average, Btu per hr	33.5	29.5	...
	36.7	...	32.6
Per cent of reference panel	100.0	88.1	89.0

The two tests were run on different days when the air temperatures were slightly different and the wind velocities quite different. The high wind velocity during the first test reduced both the surface temperature and the heat flow for the reference panel below the corresponding values for the second test even though the air temperature was higher during the first test. No doubt the flows through the two glass panels were similarly affected. The results for the clear glass and frosted glass can be compared, however, by referring the heat flows in each case to the flow through the reference panel. The results are so nearly alike that we can only conclude that there is no appreciable difference between the solar heat transmission of frosted glass and clear glass, thus confirming Dr. Houghten's analysis.—F. G. HECHLER, director, engineering experiment station, Pennsylvania State College.

NOISE LEVELS

THE EDITOR—

The article on Noise Levels—How to Figure Them, by William Goodman, published in the December HPAC, seems very worthwhile.

Example 3, which illustrated the procedure for handling several pieces of equipment in the same room, also illustrated in reverse another rather important point. If two of the three 40 db noise sources are removed the noise level, by Table 1, is still 35 + 6.2 = 41.2 db in the room, or only 4.2 db less than with all three. In other words, a quieting job on any one or even any two pieces of the equipment would never produce really successful results. It is always necessary, when there are several sources of approximately equal intensity, to operate on *all of them*, if a substantial reduction in noise level is desired.—JOHN S. PARKINSON.

OIL SUPPLY

THE EDITOR—

I understand there is a new ruling effective after March 1 which says that no more equipment can be sold for any kind of gas heating, due to a scarcity of natural gas for fuel, and the need of it for war purposes.

Now here is the dope as far as the territory near Kansas City is concerned. We have three large refineries in this region, and the crude for these refineries is supplied by pipe lines from the large oil fields of Kansas, Oklahoma and Texas. This means that as long as these refineries produce gasoline, and especially aviation gasoline, that there will be an abundance of fuel oil produced here.

It is evident that no railroad cars or other mode of transportation is involved to get this oil to this market.

There are several large war production plants near here that will use an enormous amount of coal and natural gas.

Would it not be common sense if the manufacturers of oil burning apparatus were allowed to supply enough equipment to use this surplus fuel, which is being produced in this locality?—H. B. SIEMON, district representative, Century Engineering Corp.

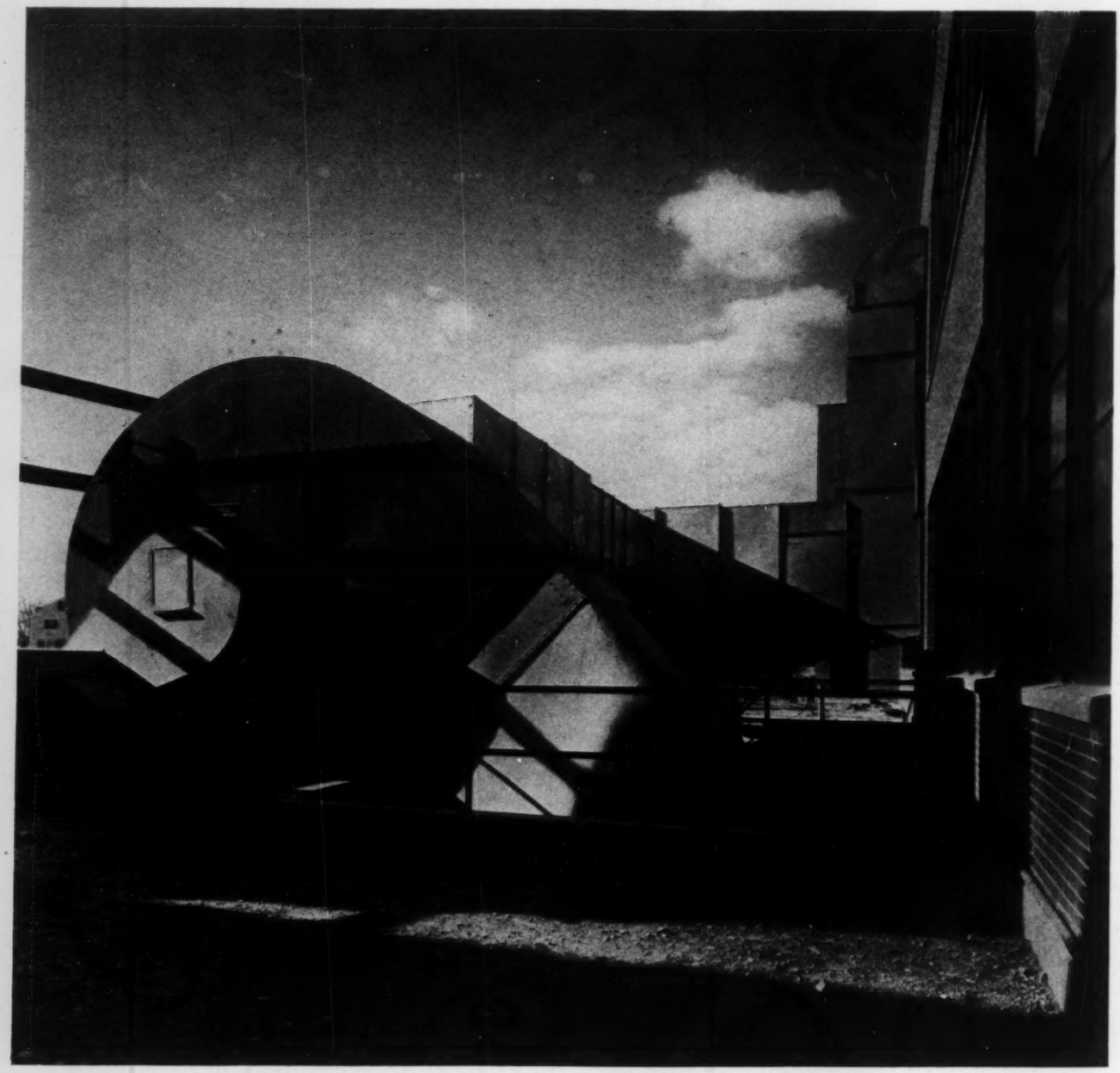
PRICE CEILINGS ON BOILERS AND RADIATORS STUDIED

Following industry meetings held last month, the Office of Price Administration is investigating by questionnaire manufacturing costs of cast iron boilers and radiators to ascertain whether recent price increases are justifiable and for probable issuance of permanent price ceilings within 30 days.

NEW PLANT FOR FLUORESCENT LAMP PRODUCTION

Hygrade Sylvania Uses Concrete Pipe for Ducts

The ventilating system which provides comfortable, dustfree conditions in the new Hygrade Sylvania Corp. fluorescent lamp plant centers in this large unit alongside the plant. Air is washed and filtered in the chambers just beyond the large fan housing in the left foreground. It is then distributed to the underfloor network of concrete pipes through the large duct which disappears below ground in the foreground. Air that is to be recirculated is taken from the interior through the ducts leading from the first and second floor to the unit, which washes and cools or heats this air before returning it to the extensive duct system



Fluorescent lamp production for the Hygrade Sylvania Corp. is now centralized at a new plant which was recently completed by the Austin Co., the engineers and builders. There is an unobstructed manufacturing area 100 ft wide and 380 ft long, entirely free from inside columns, on the second floor of the plant.

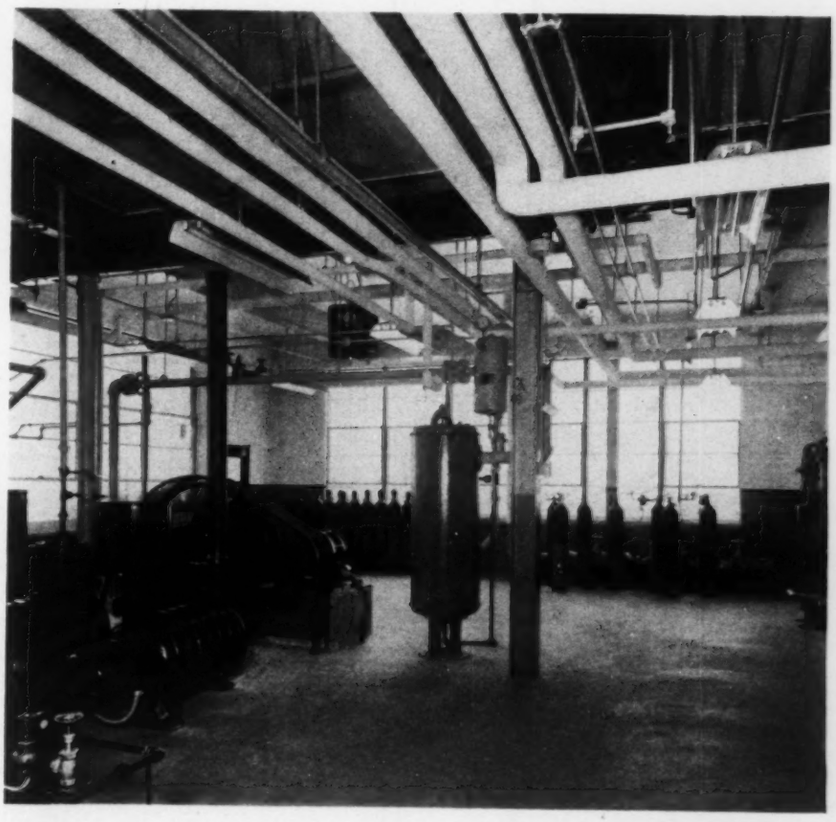
A ventilating system designed to maintain dustfree conditions and comfort temperatures throughout the plant is featured by the extensive use of reinforced concrete pipe. Outside air is washed and filtered in a series of chambers at ground level outside the building proper, where hot water lines and deep well water will be used for central heating and cooling. The air is distributed through an underground system of 400 lineal ft of concrete pipe up to 8 ft in diameter. This has been laid in the ground and covered by the fill underlying the concrete floor.

Ducts leading directly from this network of pipe have been brought up alongside the first floor columns with outlets about 2 ft above the floor at each level. The used air can be either recirculated through the return ducts to the central system or it can be exhausted through windows or 36 in. ventilating fans of 15,000 cfm capacity above the main manufacturing area. Air from bakers and from the coating room all on the first floor is exhausted direct to the outside by a network of overhead ducts.

Service facilities required for the distribution of gas, compressed air, combustion air and power for lighting, manufacture and lamp testing have been carried direct to equipment locations throughout the plant, for maximum safety and convenience in operation. A loudspeaker system with 22 outlets in various manufacturing departments is used to carry musical recordings throughout the plant, which serves to break the monotony of repetitive work.

A completely equipped maintenance shop; a pump room, where air compressors, special controls for regulating pressure of incoming gases and other equipment, are situated; as well as a boiler room in which two 150 hp stoker fed boilers and a small hot water heater are housed, are in a wing adjoining the main manufacturing area.

The first floor coating room (*above*) which occupies the entire background on the right of the aisle, is specially heated and ventilated through the large duct which is shown here. After coating the tubes are placed in bakers. After inspection they are conveyed to the floor above



Gas used in manufacturing operations enters the building through a 12 in. welded spiral pipe, which is seen overhead in the view here of the pump room. The gas pressure is reduced or increased, according to the particular process needs. All special gases, vacuum, compressed air and steam lines are controlled from this room, which is alongside the boiler room in the special service wing

17 Ways to Prevent WELDING FIRES

SUMMARY—The disaster to the former "Normandie"—renamed the "Lafayette"—serves as a pointed lesson to all using welding and cutting apparatus, for sparks from a welding or cutting torch apparently were the cause. . . . . Two years ago, the International Acetylene Association issued a pamphlet on safe practices for installation and operation of oxyacetylene welding and cutting equipment, from which the material on fire prevention given here has been taken. . . . . Carelessness must always be prevented, especially in wartime production, for its results can be just as effective in delaying our victory as the deliberate acts of enemy agents trained for sabotage

FIRES must be prevented by education of the operators and careful supervision. Carelessness must be prevented. As the use of the oxyacetylene process increases, entirely preventable fires have been increasing at an unnecessary rate. The importance of this will be realized when it is considered that any fire, however small, may be the start of a conflagration.

Safeguards have been built into the equipment and are continually being studied so that accidents may be minimized by the use of proper apparatus. On the other hand, fires at or near the point of operation are almost always due to carelessness and, being strictly preventable, should be eliminated, or at least reduced to a minimum.

Fires rarely occur where oxyacetylene equipment is set up for production work either in welding or cutting, because reasonable safeguards can be built into the setup, and it has been found that the majority of fires occur from portable equipment, many times in the hands of outside contractors doing a specific repair or alteration job, or in the hands of a plant repair gang who do not come under the immediate supervision of the foreman in charge of the part of the plant where the work is to be done.

Most fires are started from molten metal or slag thrown off by cutting operations, which sometimes fly or roll considerable distances without being noticed by the operator. Welding or other torch operations may also be the source of fires. Smoldering fires may be started which are not apparent when the work is completed and later burst into flames when no one is present. Sparks or the flame itself, in the presence of flammable liquids or vapors, may start fires immediately.

Experience has shown that sparks may lodge in cracks in woodwork, or fall into oil soaked engine pits, or ignite various materials such as tarpaulins, paint residues, oily waste, combustible materials in storage, such as waste paper, soiled rags, excelsior wrappings, wood chips, pads and combustible refuse.

Experience has shown that workmen do not always fully appreciate how far sparks can travel, or how easily they get into unseen corners or crevices. Even asbestos curtains as protection for combustible material are not always effective unless their installation is carefully supervised, as the sparks may fly under and beyond them. Fire extinguishers approved for the type of fire that may be encountered should be provided.

Management is urged to insist on the observance of the following simple precautions, particularly where portable apparatus is involved:

1) Do not use the cutting or welding flame where an open flame of any kind would be dangerous, as in or near rooms containing flammable vapors, or liquids, lint, dust or loose combustible stock.

2) Be sure that cutting and welding equipment is not used near dipping or spraying rooms or rooms containing loose, readily combustible material unless there is absolutely no possibility of the vapors or of sparks passing through broken or open windows, open doorways, or cracks or holes in walls or floors.

3) When cutting or welding work must be done on an automatic sprinkler system, or where the sprinklers are cut off for any reason, extra precautions must be used and the proper authority notified.

4) If the work can be moved, it is far preferable to take it to a safe place for cutting or welding rather than perform the work in a hazardous location. A non-combustible room or building or one provided with an automatic sprinkler system is considered a safe location.

5) Where welding or cutting has to be done in the vicinity of combustible material, special precautions should be taken to make certain that sparks or hot slag—*from cutting operations particularly*—do not reach combustible material and thus start a fire. If the work cannot be moved, exposed combustible material should, if possible, be moved to a safe distance away, say 30 or 40 ft. Sweep floors clean and wet them down before starting work. Wooden floors should preferably be covered with metal or other suitable non-combustible material where sparks or hot metal are likely to fall. Wherever there are floor openings or cracks in the flooring, it is also advisable to make certain that there are no highly combustible materials on the floor below, where they would be exposed to sparks which might drop through the floor. Observe the same precaution with regard to cracks or holes in walls, open doorways and open or broken windows.

6) Watch the sparks and hot slag. See that they do not come in contact with combustible material, do not lodge in floor cracks, and do not drop through holes to the floor below. Use sheet metal guards or asbestos curtains where needed. Make sure that the guards and curtains are adequate. Because hot slag may roll

along the floor for considerable distances, it is important when using asbestos blankets as a curtain that no openings exist where the curtain meets the floor. Avoid the use of tarpaulins, as experience has shown that they do not provide adequate protection.

7) When any non-routine welding or cutting repair or other work is to be done where combustible material may be exposed in a plant, a work order or a written authorization should be obtained from the proper authority in the organization having supervision over fire protection.

8) Station extra men with small hose, chemical extinguishers or fire pails nearby when the nature of the work requires that torches be used near wooden construction or in locations where the combustible material cannot be removed or protected. It is advisable to carry as regular equipment a fire exinguisher approved for the type of fire that may be encountered.

9) In sprinklered buildings, *maintain sprinkler protection without interruption while cutting torches are being employed.* If repairs should be necessary to sprinkler systems, plan work so that any flame cutting and sprinkler repairs are done at different times.

10) Watch should be kept at the scene of the cutting work for ½ hr after completion to make sure that sparks have not started smoldering fires.

11) Dusty and gassy atmospheres in certain mines, mills, industrial plants and plants spraying lacquers and the like, require extra precautions to avoid explosions or fires from electric sparks, matches and open fire. Welding or cutting in such possibly hazardous places should, therefore, be done only when proper precautions have been taken and only after the responsible official in charge has inspected the situation and has personally given instructions to proceed.

12) Never do any hot work, such as welding or cutting on used drums, barrels, tanks or other containers, until they have been cleaned so thoroughly as to make absolutely certain that there are no flammable materials present or substances such as acids which, under certain conditions, may produce flammable gases or vapors. Where steam is available, this may be used to remove materials which are easily volatile. Washing with strong caustic soda solution will remove heavier oils. Even after thorough cleansing, the container should, wherever possible, be filled with water before any welding, cutting or other hot work operation is performed. In practically every case it will be found possible to place the container in such a position that it can be kept filled with water to within a few inches of the point where welding or cutting is to be done. In doing this, care should be taken to make sure that there is a vent or opening to provide for the release of heated air from inside the container. This can usually be done by opening the bunghole, handhole or other fitting which is above water level. Where it is not practical to fill with water, carbon dioxide or nitrogen may be used for added protection.

13) Where alterations or repairs are being carried out on containers that have held flammable substances, periodic examination of the air contents of the vessels should be made from time to time wherever possible, by a detector of combustible gases where such an instrument is available. Although the vessel may have been steamed and flushed with caustic soda, there may still be traces of oil or grease under seams, and the heat of the welding or cutting operations may cause such oil or grease to give off flammable vapor to the extent that an explosive mixture may be formed inside of the tank. If possible, maintain an atmosphere of carbon dioxide or nitrogen in the vessels while under the process of repair. The use of carbon tetrachloride for this purpose is not recommended, as carbon tetrachloride gives off poisonous vapor when heated.

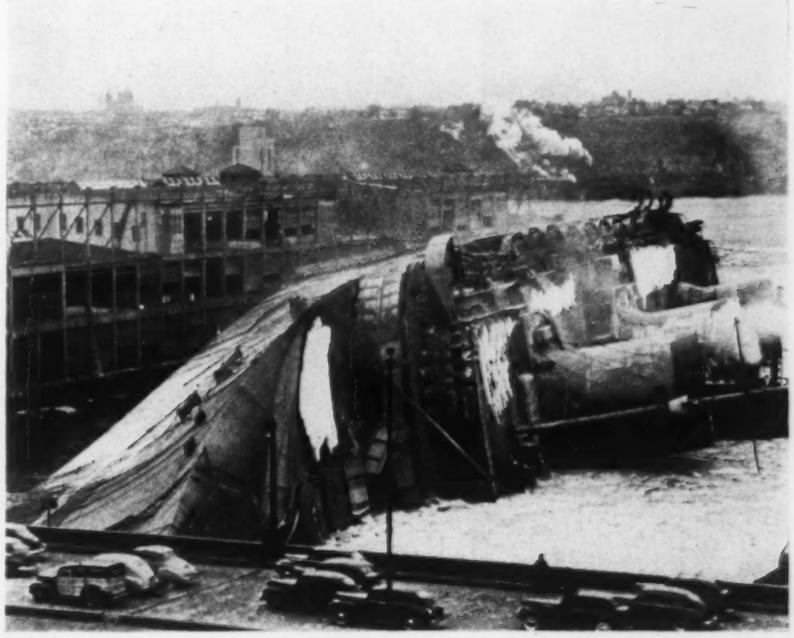
14) Never put down a torch unless the oxygen and acetylene have been completely shut off. Torches should never be hung from regulators or other equipment so that the flame can come in contact with the oxygen or acetylene cylinders, even though the workman thinks the valves are shut off.

Excess lengths of hose in use should not be wound around or over cylinders or regulators.

15) Keep acetylene equipment in good order. Use good hose and renew it when necessary. When worn near the couplings, cut off a few inches periodically and renew the connections. Be sure that all connections are tight and not worn. Good connections between regulators and cylinder valves are particularly important. See that the threads are not crossed and that the connections are tight. Use proper adapters where necessary.

16) Mount cylinders of portable equipment securely on a cylinder truck so that the valves, regulators and other parts are well guarded and the cylinders kept in a vertical position. It is good practice to have a non-combustible barrier extending from below the top of the acetylene cylinder to a point above the oxygen cylinder when these two cylinders are close together. Locate cylinders so that valves are readily accessible at all times.

17) Do not keep unnecessary cylinders around the premises. Full cylinders not in use belong in storage places properly selected for the purpose. Empty cylinders should be promptly returned to the supplier.



The former liner "Normandie," on her side in the Hudson river after a blaze razed the inside of the 83,000 ton vessel. The thousands of tons of water poured into the ship to extinguish the fire left her so top heavy that she rolled away from the dock until her port side rested on the silty river bottom (Acme photo)

WAR PROBLEMS FORUM

How Does the Switch to Steel Affect Heating Surface Performance?

MORE ATTENTION TO TRAPPING AND PIPING, PERHAPS WATER TREATMENT, ARE INDICATED

SUMMARY—Copper and aluminum may no longer be used, because of war restrictions, for blast heating surface—except in very special cases. How does the change to steel for heating coils affect their performance? . . . . . In spite of the difference in the heat conductivities of the metals, the heat transmission through bare tube coils will be almost negligibly affected, for their heat transmitting capacity is determined by the resistance of the air film and not by the resistance of the metal itself. For finned coils, thicker and larger fins can maintain the capacity of the coil at the same level as that of copper finned coils, according to one viewpoint, although such factors as amount of prime surface present have an effect. . . . . With the same overall dimensions of the casing of the coil, fins must be thicker, which will affect the free area and consequently the air friction loss through the coil, which should be allowed for in fan selection. . . . . With steam, corrosion must be guarded against. Rapid drainage of condensate is of increased importance, so engineers must pay more attention to trapping and piping connections. . . . . Water treatment, properly applied, can do much to lengthen the life of blast heating coils

As a war measure, copper and aluminum may no longer be used in the construction of blast heating coils, except under very special circumstances. In general, because the heat conductivity of copper is many times that of steel, most engineers expect a marked reduction in the capacity of blast coils when steel is substituted for copper. Such a reduction need not necessarily follow.

A better understanding of the effect of metal conductivity on fin coils can be obtained by eliminating the complication of fins and first discussing bare tube coils alone. In spite of the large differences in the conductivities of steel and copper, the heat transmission capacity of bare tube blast coils is almost negligibly affected by a change from copper to steel. The reason that the difference in conductivity of steel and copper has little affect on the overall heat transmission of a bare coil is due wholly to the resistance of the air film on the outside surface of the coil. The resistance offered by the air film to the flow of heat is so great that the increase in resistance caused by a change from copper to steel is almost negligible in spite of the great differences in their conductivity. The performance of a bare tube coil has always been determined by the resistance of the air film and not by the material.

The conductivity of the fin material has far more effect on the performance of a finned coil than the conductivity of the material used for the walls of the tube. However, the lower conductivity of a steel fin can be offset by using thicker and larger fins. On the usual commercial blast coils, according to one viewpoint, this can be accomplished without increasing the overall dimensions of the casing. In other words, changing the wall of the tube from copper to steel has only a negligible effect on the performance of the coil, but changing the fin from copper to steel will affect the performance of the coil.

If the same overall dimensions of the coil are maintained, thickening of the fins will generally result in a smaller free area through the coil. This smaller free area through the coil, in turn, means that the air friction loss through the coil will be higher than with coils of the same capacity using either aluminum or copper fins. When selecting fans, the fact must be borne in mind that, generally speaking, the air friction loss through coils having thicker steel fins will be higher than through coils with aluminum or copper fins.

Contrasted to the above view, some engineers see reduction in capacity for the same size units, with a greater amount of prime surface used at a greater cost to offset this.

When steel coils are used, corrosion must be carefully considered and guarded against. This is true only of steam plants; no particular difficulties are experienced with corrosion in hot water heating systems. Depending upon the impurities in the condensate, sufficient corrosion to cause leaks may occur unless preventive measures are taken. Preventive measures comprise proper drainage and trapping of the coils, and perhaps protective coating of the steel and treatment of the water to render it as inert as possible to the steel coils.

Condensate Drainage—To prolong the life of steel coils, they must be drained rapidly of condensate. Perhaps the single most important factor in prolonging the life of steel coils will be adequate drainage of condensate. Engineers must pay greater attention to the trapping and piping of condensate from coils if satisfactory life is to be obtained. Traps of adequate capacity must be installed and serviced frequently to be sure they are functioning properly and not sticking. Strainers in the condensate lines ahead of all traps would be highly advisable to

prevent scale from entering the trap and keeping it from functioning.

Coils set with tubes horizontal must be pitched sufficiently so that the water will drain rapidly and freely from the tubes. Where conditions will permit, it is desirable to set the coils with the tubes vertical.

Water Treatment—Where difficulty is encountered with highly corrosive water, it might be a good plan to consult one of the reliable companies with regard to treating the water. On the larger plants, deaerating equipment for liberating free oxygen from the water is of considerable value.

Water treatment properly applied can do much to lengthen the life of coils. However, indiscriminate treatment without proper guidance from experienced people can do a great deal of harm. For this reason, so-called water treatment, unless it is controlled by means of periodic checks on the condensate itself, is not likely to be of much help.

RULES FOR SAFE STORAGE OF COAL

As a part of the victory effort to provide uninterrupted supplies of fuel to fast growing war industries, Secretary Ickes and the Office of Solid Fuels Coordination recently appealed to both domestic and industrial consumers to build stockpiles before the full effect of the war is felt and problems of coal transportation become more complicated.

Although anthracite and large sized bituminous coal require only ordinary care, piles of slack or fine bituminous coal require special attention while in storage. Such coal, however, also has been stored satisfactorily in many places by observing a few simple rules. Nearly three decades of observation and research by the Bureau of Mines have shown that the important thing is to keep air from circulating through slack bituminous coal piles. One method to accomplish this is to store the coal in layers and to compress the pile with a heavy roller.

Other aids to the safe storage of bituminous slack, according to the bureau, are keeping the coal away from external sources of heat such as steam pipes, warm flues and boiler settings; avoiding drafts through air passages made by sticks, timbers and pipes; not permitting old coal to accumulate in corners or on the bottom of bins or piles; and not allowing foreign combustible matter such as oily rags, paper and waste to become mixed with the coal.

A regular check on the temperature of a coal pile will indicate in advance of overheating. This can be done by seeing if an iron rod driven into the coal is heated on removal or by a thermometer inserted through a pipe. When the temperature reaches 120 F, it is a sign that too much heat is being generated within the pile.

Sealing the top and sides of a large coal pile with an airtight continuous layer of fine coal, plus a second outside covering of lump to prevent wind and rain erosion, has been found practical and effective by one large industrial concern. Coatings of asphalt also have been used with success to preserve very large coal piles.

When spontaneous heating has progressed to a great degree in a coal storage pile, the only thing to do is move the coal so that it can cool off, according to the bureau. Using water to put it out may be effective for the moment, but in many cases it only delays the necessity of moving the coal.

The tendency to heat in storage varies with the bituminous coals. Certain low rank coals of the lignite and sub-bituminous classification are subject to more rapid spontaneous heating processes than the higher rank bituminous coals. Therefore, in storing large quantities of such coal, the Bureau of Mines recommends that information on the coal be obtained locally.

WELDING ELECTRODE CONSERVATION

The necessity of conserving materials in the war effort is nowhere more urgent than in the use of welding, says Clayton B. Herrick, welding engineer, the Lincoln Electric Co. In order that welding may contribute its utmost potentiality in war production, it is important that welding materials be utilized to maximum advantage. This applies particularly to welding electrodes.

One way to conserve electrodes is to use them down to the minimum stub end. Remember, says Mr. Herrick, that the electrode can be used the entire length of its coated surface. Leaving any more than a minimum stub end is an obvious waste. By using care in gripping the electrode at its extreme end in the holder and burning it down to the maximum extent, the operator is rendering a patriotic service in saving electrode.

Method employed by one welding shop to illustrate effect of stub end loss on electrode costs

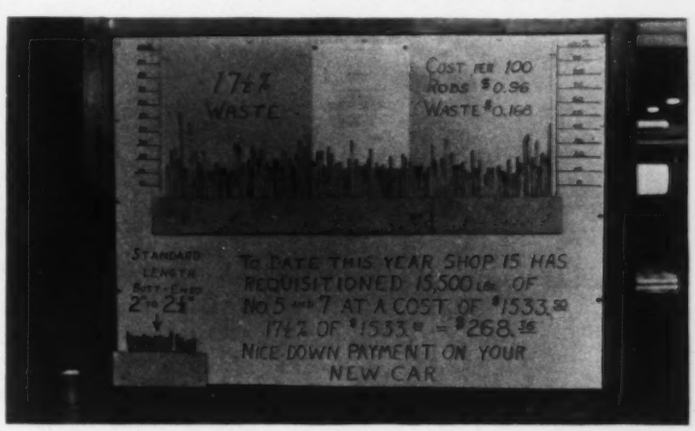

17½ WASTE
COST PER 100 RODS $0.96
WASTE $0.168
STANDARD LENGTH BUTT-END 2" to 2½"
TO DATE THIS YEAR SHOP IS HAS REQUISITIONED 15,500 Lbs. OF No. 5 and 7 AT A COST OF $1533.50
17½ OF $1533.50 = $268.36
NICE DOWN PAYMENT ON YOUR NEW CAR

Photo courtesy Westinghouse

Red-hot pipe is here being cut into accurate lengths as the pipe races out of the mill. The saw, in effect, runs back and forth along the pipe and for a brief instant it is moving at the same speed as the pipe. By synchrotie and other electrical controls the timing is done automatically and so accurately that cuts are made within 2 in. of the exact length

CUTTING PIPE ON THE RUN

MOST persons experience difficulty in sawing through a board squarely on the mark even when it is held steady. Consider then the problem of cutting accurately to length red-hot pipe coming out of a mill at 7 fps. Add to this the fact that the speed of the moving pipe may change in a few minutes, because the speed of the pipe through the furnace is changed to maintain the correct temperature. Also pipe sizes vary from ⅜ to 4 in. in diameter.

The new "hot saw," as it is called, continuously rotates at high speed. The saw carriage moves parallel to the advancing pipe with a reciprocating motion and at the proper instant in the reciprocating cycle when the saw carriage has caught up with the pipe and is running with it at the same speed, it tilts forward into the pipe. The trick is, of course, to coordinate this motion with that of the pipe, regardless of how the speed of the pipe may vary. The saw carriage is driven by a cam continuously. By moving the carriage driving link farther out or closer in to the center of the cam any carriage speed can be obtained. Coordination of all these complex motions and the movement of the saw are accomplished by electrical controls in which synchroties figure prominently. The older methods used mechanical aids, such as clutches.

NEW WINDOWLESS PLANT TO HAVE LAKE ON ROOF

Ground was broken last month for a new factory addition for the Monroe Calculating Machine Co. E. F. Britten, Jr., president, states that the four story building will be windowless, in order to secure the best light for working and the best air conditioning. This feature would also simplify blackout.

The roof is to be covered with a 3 in. layer of moving water, provided from driven wells. The purpose of this is to establish cool temperatures in summer, and to assist insulation in winter.

AIR IN CONTACT WITH WATER

Analyzing Air Conditioning and Heat Exchange Processes with the Psychrometric Chart . . . By William Goodman

THERE is hardly a process in air conditioning in which air and water are not brought into direct contact with each other; familiar examples are air washers, cooling towers and evaporative condensers. Even in cooling coils in which the cooling water flows inside of tubes, the air is brought into direct contact with water—only in this case the water lies on the surface of the coil and is condensed from the air.

Because air conditioning equipment so frequently involves direct contact of water and air, a thorough understanding of the action that takes place between the water and air can be very helpful in analyzing the performance of equipment and in understanding the operation of air conditioning systems. The psychrometric chart lends itself beautifully to the analysis of the action of air and water in direct contact with each other. By using the psychrometric chart the change in the state of the air can be traced directly, and the action visualized in a direct and clear-cut fashion. In no other way can these processes be understood so clearly.

No attempt will be made here to analyze the performance of equipment. The action of air and water in direct contact with each other in different types of apparatus will be explained so that the differences involved in various types of conditioning processes can be readily understood. We will attempt to cover in a simple and *non*mathematical manner *only* the fundamentals involved.

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SUMMARY—Processes in which air and water are brought into direct contact with each other are quite common in air conditioning; familiar examples are air washers, cooling towers and evaporative condensers. The condition of the air as it passes through such equipment can be represented either by a curve or straight line on the psychrometric chart. Such a curve is known as a "condition curve," because any point on the curve represents the condition of the air at various stages in the process. . . . . There is presented in the group of articles of which this is the first, the method of determining the state of the air while it is in contact with the water. Typical condition curves for a number of common processes are presented and discussed. A thorough understanding of the condition curves obtained for various types of apparatus will be of considerable value to those who design air conditioning systems. . . . . The author is consulting engineer, the Trane Co., and a member of HPAC's board of consulting & contributing editors

Air Films on Water Surfaces

Even though the flow of air past a surface may be turbulent, there is always a thin, almost stationary, layer of air in immediate contact with the surface. This layer of air constitutes what may be called the *surface film* of air. A surface film of air is always found on any object past which air is moving.

If air is in contact with a spray of fine drops of water, each drop of water may be regarded as being surrounded by a surface film of air. Similarly, if the water forms a thin film on a surface such as a cooling coil, the film of air may be regarded as covering the entire surface of the water film. In discussing the subject of air in contact with water, a much better understanding of many phenomena can be obtained by considering the surface film of air in contact with the water surface.

Because of the intimate contact between the air and water films, the surface film of air in contact with the water is assumed to be saturated and at the same temperature as the water itself. Deductions based on this assumption lead to results which check with experiment. Obviously, if the surface film of air is saturated at the temperature of the water, the state of this surface film can be represented on either of the skeleton psychrometric charts of Fig. 1 by a point such as *3* on the saturation curve. The temperature of the saturated air at *3* is the same as the temperature of the water. The left chart represents the dehumidification of air, and the right represents the humidification of air.

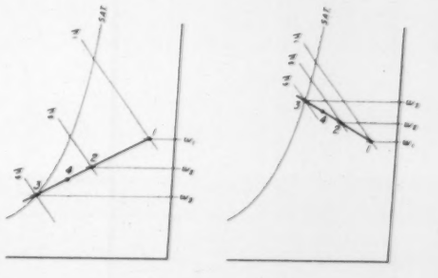
Symbols

h = enthalpy of air-vapor mixture, Btu per lb of dry air in the mixture;
t = dry bulb temperature, F;
t' = wet bulb temperature, F;
w = absolute humidity of the air-vapor mixture, lb of moisture per lb of dry air in the mixture.

"Straight Line" Principle

As shown by Keevil and Lewis [Dehumidification of Air, Industrial & Engineering Chemistry, October, 1928, p. 1058], when unsaturated air is brought into contact with water at *constant* temperature, the change in the state of the unsaturated air takes place along the straight line joining the point representing the initial state of the unsaturated air and the point on the saturation curve representing the constant temperature of the water. Thus, in Fig. 1, if unsaturated air initially in the state represented by point *1* is brought into contact with water at the constant temperature represented by point *3*, the change in the state of the air takes place along line *1-3*. If the temperature of

Fig. 1—Change in state of air that is in contact with water at constant temperature takes place along straight line. At left, cooling and dehumidification; at right, cooling and humidification process



the water remains constant, the final state of the air will be represented by a point such as *2* or *4* on line *1-3*.

As previously mentioned, the point on the saturation curve representing the constant temperature of the water may also be regarded as the point representing the state of the saturated air film in contact with the water. On the psychrometric chart, the point representing the final state of a mixture of air from two separate sources always lies on the straight line joining the initial state points of the two air components [HPAC, January, 1940, p. 6]. By analogy, therefore, the change in the state of unsaturated air in contact with water at constant temperature may be regarded as being due to the mixing of the unsaturated air in the main stream with the saturated air in the surface film. This mixing analogy, which has been discussed by Carrier [The Contact-Mixture Analogy Applied to Heat Transfer with Mixtures of Air and Water Vapor, Transactions, American Society of Mechanical Engineers, August, 1937, p. 49], is frequently of value in discussing the exchange of heat and moisture between unsaturated air and water.

From the discussion in the preceding paragraphs, the following general principle may be stated: *If the temperature of the saturated surface film of air remains constant during the entire conditioning process, the change in the state of the main body of unsaturated air will take place along a straight line drawn from the point representing the initial state of the main body of air to the point on the saturation curve representing the state of the saturated surface film of air.* By using this "straight line" principle, many phenomena in air conditioning can be interpreted in a logical manner, and invariably the interpretation can be checked experimentally.

Equilibrium Water Temperature

The temperature of the saturated surface film of air will not always be constant. Whether the temperature of the saturated air film will vary or will be constant depends upon the type of air conditioning process. In this, and the following few sections, only the case in which the temperature of the surface film is constant will be considered. Processes with variable surface temperatures will be discussed later.

As previously stated, the temperature of the saturated surface film of air may be assumed to be the same as the temperature of the water with which it is in contact. However, the temperature of the water with which the air film is in contact need not necessarily be equal to the temperature at which the water is initially supplied to the conditioning unit. It is important to differentiate between the *initial temperature* at which the water is supplied and the *equilibrium temperature* that the water will assume when brought into contact with air.

For a constant surface film temperature, the change in the state of the air takes place along the line joining the initial state of the air with the state of the surface film. Consequently, the temperature of the saturated surface film of air must be equal to the temperature at the point where the straight line intersects the saturation curve in Fig. 1. Inasmuch as the temperature of the saturated surface film of air is the same as the temperature of the water with which it is in contact, it is obvious that the *equilibrium temperature* of the water is determined at the point where the straight line intersects the saturation curve. Thus, in either of the illustrations of Fig. 1, the *equilibrium temperature* of the water for the process represented by line *1-2* is the temperature at point *3*.

Adiabatic Processes

An adiabatic process is defined as one which takes place with no loss or gain of heat from an external source. Thus, when water and air are mixed together adiabatically, no heat is added to—or removed from—the insulated chamber in which the mixing process is taking place. On the other hand, in a nonadiabatic process, heat may be added or removed (by a coil, for example) while the air is brought into contact with the water. The evaporative condenser is a good illustration of the nonadiabatic mixing of air and water.

As has been shown in an earlier article [HPAC, August, 1939, p. 486, and September, 1939, p. 550], in an adiabatic process, the change in the state of the air takes place along a straight line when the air is brought into contact with water, and the *slope* of this straight line is determined wholly by the *initial temperature* of the water supplied to the conditioning chamber. Also, in this earlier article, the straight line along which the change in the state of the air takes place was named the *ratio line*. For convenience, the term "ratio line" will be used throughout the balance of this article for a straight line such as *1-3* of Fig. 1.

Although the initial temperature of the water supply determines the slope of the ratio line, the point

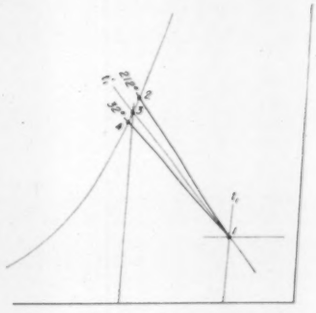


Fig. 2—Ratio lines corresponding to water at 32 and 212 F. Note that even though the range of water temperatures is fairly large, all of the ratio lines for water fall in a small sector. In this illustration, angle between lines is exaggerated for clarity

where the ratio line intersects the saturation curve determines the equilibrium water temperature. Thus, in Fig. 2 the slope of the ratio line *1-2* is determined by the initial temperature of the water supply, but the equilibrium temperature that the water assumes when it is brought in contact with the air is read at point *2* where the ratio line intersects the saturation curve.

In Fig. 2, ratio lines are shown for adiabatic processes in which water is supplied at initial temperatures ranging from 32 to 212 F. Also, the initial wet bulb temperature of the air is represented by line *1-3*. It is evident from this illustration that the equilibrium temperature changes only slightly for wide variations in the initial temperature of the water supply. Furthermore, in most cases, the equilibrium temperature will be numerically close to the wet bulb temperature of the air. Nevertheless, equilibrium tem-

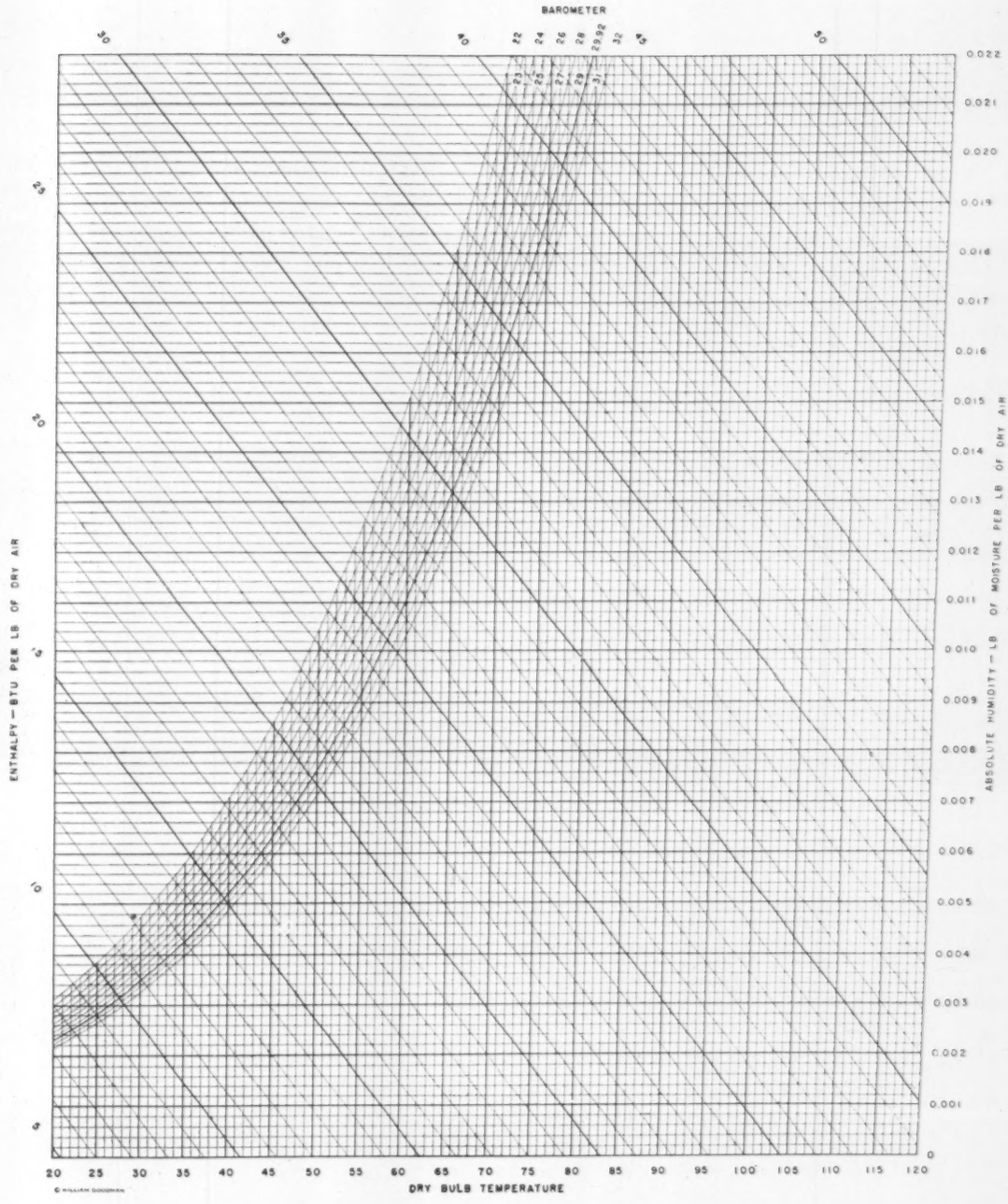

BAROMETER
ENTHALPY—BTU PER LB OF DRY AIR
ABSOLUTE HUMIDITY—LB OF MOISTURE PER LB OF DRY AIR
DRY BULB TEMPERATURE
20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120

Fig. 3—Psychrometric chart for middle range of temperatures from 20 to 120 F
[See June, 1939, HPAC for full explanation of use.]

peratures are explained in some detail here because an understanding of these temperatures is essential to a proper comprehension of many phenomena involving the direct contact of air and water with each other.

The tendency to assume that the equilibrium water temperature is the same as the initial water temperature should be guarded against. If the amount of water supplied is exactly equal to the amount that is evaporated, which must be the case if the process is to be adiabatic, the water cools immediately from its initial temperature to its equilibrium temperature. The heat surrendered by the water in cooling provides a small part of the heat required for evaporating the water into the air; the balance of the latent heat is supplied by the cooling of the air. This process is analogous to blowing water from a high pressure boiler into the atmosphere. Part of the water immediately flashes into steam as the water cools to the temperature corresponding to atmospheric pressure. A further explanation of the cooling of the water to the equilibrium temperature will be given in a later section, entitled Limiting Final Temperature of Water.

As is evident from Fig. 2, the ratio line for warm water is steeper than for cold water. For the same increase in the moisture content of the air, the fall in the dry bulb tem-

perature of the air is smaller along ratio line *1-2* than along *1-4*. When warm water is supplied, part of the latent heat of evaporation is supplied by the cooling of the water itself; therefore, the air in providing only the balance of the latent heat need not cool as much as if cold water were supplied. If cold water were supplied, it would be necessary for the air to cool a greater amount to evaporate the same amount of moisture because, in this case, the heat surrendered by the air must not only be sufficient to evaporate the water but also to raise its temperature.

As has been shown earlier [HPAC, January, 1940, p. 9], in the commonly used air washer through which a large weight of water is constantly recirculated without either being heated or cooled outside of the spray chamber, the change in the state of the air also takes place along the ratio line whose slope is determined by the temperature of the makeup water. Contrary to popular belief, the temperature that the spray water will assume is not equal to the wet bulb temperature of the air, although the equilibrium temperature is frequently close to the wet bulb temperature. As in all other adiabatic processes, the equilibrium temperature of the spray water can be read on the psychrometric chart at the point where the ratio line intersects the saturation curve. However, for many purposes, the wet bulb temperature of the air may usually be used as a good approximation to the temperature that the water will actually assume.

[The next of these articles will appear in April.]

How to Figure Duct Sizes

FOLLOWING is a supplement prepared by William Goodman showing the development of the equations used in computing his chart for determining pressure loss due to friction in ducts, Fig. 1 on p. 106 of the February, 1942, issue of HEATING, PIPING & AIR CONDITIONING. The author is consulting engineer, the Trane Co., and a member of HPAC's board of consulting & contributing editors:

The friction factors used in computing the chart are based on the following equation given by Schmieler, Houghten and Olson[1] for the friction coefficient in round ducts.

$$f = \frac{0.131}{D_F^{0.3} V_s^{0.17}} (u/d)^{0.17} \quad \text{.....[a]}$$

They derived this equation from an analysis of the ASHVE laboratory tests reported by Houghten, Schmieler, Zalovcik and Ivanovic.[2]

For dry air, the kinematic viscosity (u/d) is 16.27×10^{-5} sq ft per sec at 70 F. Substituting this value into equation [a] and converting velocity to feet per minute, the following equation is obtained.

$$f = \frac{0.05965}{D_F^{0.3} V^{0.17}} \quad \text{.....[b]}$$

Equation [a] is based on tests of round ducts having 40 joints per 100 ft. In the light of current practice in regard to duct joints, it would appear that this equation would give friction factors which are safe. Nevertheless, the friction losses obtained from the chart of Fig. 1, which are based on the friction factors obtained by means of equation [a], are lower than the friction losses computed by means of the chart on p. 574 of the 1941 issue of the ASHVE Heating, Ventilating, Air Conditioning Guide. The pressure losses computed by means of Fig. 1 are roughly 35 per cent lower than the losses computed from the ASHVE Guide. In spite of this, it is probable that the friction losses computed by means of the chart of Fig. 1 will be reasonably close to the friction losses that will be obtained in actual installations. An allowance of 40 joints per 100 ft should certainly be adequate for both the average number of joints used and for minor irregularities in duct construction. Other losses, such as those due to bends, enlargements, and so forth, must of course be figured in addition.

Changes in the kinematic viscosity of air have little effect on the friction factor computed by means of equation [a]. Strictly speaking, equation [b] is valid only for air at 70 F. However, the value of the friction factor computed by means of this equation would be in error only by approximately +2 per cent if the air were 32 F, and only by approximately −5 per cent if the air were at a temperature as high as 160 F.

By making appropriate substitutions, equation [b] reduces to

$$f = 0.05752 \frac{A^{0.02}}{Q^{0.11}} \quad \text{.....[c]}$$

The pressure loss chart of Fig. 1 is based on the familiar Fanning equation

$$p = f \frac{d}{D_F} \left(\frac{V}{1096.6} \right)^2 \quad \text{.....[d]}$$

For standard air whose density is 0.075 lb per cu ft, equation [d] reduces to

$$p = \frac{f}{D_F} \left(\frac{V}{4005} \right)^2 \quad \text{.....[e]}$$

Substituting [c] into [e] and making other changes, equation [e] reduces to

$$p = 0.351 \left(\frac{S}{A^{2.08}} \right) \left(\frac{Q}{4005} \right)^{1.83} \quad \text{....[f]}$$

This equation is applicable regardless of the shape of the duct. For round ducts, equation [f] reduces to

$$p = \frac{2.265}{D_F^{4.99}} \left(\frac{Q}{4005} \right)^{1.83} \quad \text{.....[g]}$$

Equation [g] finally reduces to the following equation, which was actually used in constructing the chart of Fig. 1.

$$Q = 3.045\, p^{0.546}\, D^{2.71} \quad \text{.....[h]}$$

In equation [h], note that the unit of D is inches whereas it is feet in the rest of the equations in this section.

For computations in terms of air velocity, equation [e] can be reduced to the following form by means of equation [b].

$$p = \frac{1.456}{D_F^{1.3}} \left(\frac{V}{4005} \right)^{1.83} \quad \text{.....[i]}$$

Equivalent Rectangular Ducts

It is apparent from equation [f] that the pressure loss for a given quantity of air in round and rectangular ducts will be exactly the same if

$$\frac{S_D}{A_D^{2.08}} = \frac{S_R}{A_R^{2.08}} \quad \text{.....[j]}$$

Substituting the appropriate quantities for round and rectangular ducts, this equation reduces to

$$\frac{D}{b} = 1.266 \frac{\left(\frac{a}{b} \right)^{0.001}}{\left(1 + \frac{a}{b} \right)^{0.202}} \quad \text{.....[k]}$$

This equation was used in computing the values in Table 1 on p. 109 of the February HPAC. However, this equation cannot be used to plot the scales of the long and short sides of the equivalent rectangular ducts on the pressure loss chart of Fig. 1. Instead of equation [k], an empirical equation must be used. The empirical equation used for plotting the scales of Fig. 1 is

$$\frac{D}{b} = 1.1 \left(\frac{a}{b} \right)^{0.64} \quad \text{.....[l]}$$

Values computed by means of equation [l] deviate from those computed by equation [k] by less than 2 per cent for aspect ratios from one to 10. For aspect ratios from 10 to 15, the deviation is less than 4 per cent. This is sufficiently accurate for all duct design work. The scales of the long and short sides of Fig. 1 were plotted from equation [l]. Incidentally, for aspect ratios from 15 to 20, equation [l] deviates from equation [k] by less than 5½ per cent.

Symbols

a = short side of rectangular duct, in.;
A = area of duct, sq ft;
A_D = area of round duct, sq ft;
A_R = area of rectangular duct, sq ft;
b = long side of rectangular duct, in.;
d = density of air, lb per cu ft;
D = diameter of round duct, in.;
D_F = diameter of round duct, ft;
f = friction factor;
p = pressure loss due to friction, in. of water per 100 ft of duct length;
Q = air quantity, cfm;
S = perimeter of duct, ft;
S_D = perimeter of round duct, ft;
S_R = perimeter of rectangular duct, ft;
u = viscosity of air, lb per ft sec;
V = velocity of air, fpm;
V_s = velocity of air, fps.

[1] Analysis of the Factors Affecting Duct Friction, ASHVE Journal Section, HEATING, PIPING & AIR CONDITIONING, March, 1940, pp. 202-206.
[2] Frictional Resistance to Flow of Air in Straight Ducts, ASHVE Journal Section, HEATING, PIPING & AIR CONDITIONING, December, 1938, pp. 791-801.

INDUSTRIAL HEALTH DEFENSE

Dust Counts and Their Significance

THE GREENBURG-SMITH IMPINGER AND THE SEDGWICK-RAFTER AND HATCH CELLS . . . . . BY N. R. BERNZ

SUMMARY—Considerable attention has been focused in recent years on the conservation of health in industry, a subject which becomes of increased importance in connection with the production for victory program. Mr. Bernz, of the Fidelity and Casualty Co. of New York, discusses here the methods employed in the evaluation of dust exposures, reviewing the types of sampling and counting instruments and the various factors involved. . . . This month, he covers the Greenburg-Smith impinger—best known of the sampling devices—and the Sedgwick-Rafter and Hatch cells for dust counting. In future articles, he will take up other dust counting and sampling methods, and the choice of instruments, evaluation of dust counts, etc. His material is based on a paper read before the Greater New York Safety Congress

IN RECENT years considerable attention has feen focused on the conservation of health in industry. New state compensation laws have been enacted and old ones revised for the purpose of including coverage for specific—and in some instances all—diseases whose origin might in some way or other be associated with a man's occupation. Industrial health defense increases in importance today because of our production for victory program.

Of the recognized occupational diseases to date, none has received more widespread attention than silicosis. A great deal has been said and written on this subject in all its ramifications, and the term "silicosis" is today generally understood to refer to a specific lung disease caused by the inhalation of silicon dioxide in free form, as it occurs in the minerals quartz, chalcedony, crystobalite, tripoli and flint as well as in numerous other modifications.

The purpose here, however, is not to debate the pathology of silicosis or pneumoconiosis in general, which are strictly medical subjects, but to discuss methods employed in the evaluation of dust exposures and review the various factors involved.

In order to evaluate the dust exposure of an industrial operation with respect to its potential occupational disease producing hazard, it is necessary to know the composition of the dust involved and the amount, within a certain size range, that is dispersed per unit volume of air in the breathing zone of the men engaged in the operation. These two factors combined constitute an index which may be referred to a toxicological scale, dust standard or code for the proper evaluation of the dust exposure.

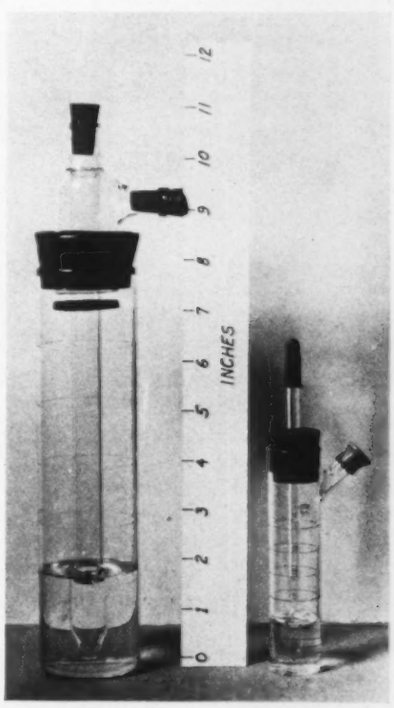
By the term "toxicological scale" is understood somewhat of an empirical classification of dusts as they occur in aerosols, in which their concentration and composition as well as duration of exposure of men engaged in dusty atmospheres have been considered against the degree of lung pathology produced. Such classifications have resulted in the development of dust standards and the promulgation of codes, based on a great number of pathological studies and technical investigations in various parts of the world.

A typical example of such legislation is the industrial code of the New York state department of labor pertaining to control of silica dust (free silicon dioxide) in rock drilling. This code specifies in effect a permissible dust concentration of 100 million particles per cubic foot of air, provided the free silica concentration is less than 10 per cent. When this percentage exceeds 10, the maximum permissible concentration limit is set at 10 millions.

In view of the consensus of lung pathologists to the effect that the amount of uncombined silica in a dusty atmosphere is one of the outstanding factors in its classification with respect to disease, the percentage of free silica should always be stated when a dust concentration is recorded for the purpose of evaluating the exposure. An exception to this rule is the case of a group of fibrous silicates, known as asbestos. According to medical authorities, asbestos is just as prone to produce lung pathology as silicon dioxide in free form, and in some instances even lower safe limits have been established for the former substance with respect to atmospheric concentrations. Whenever a dust concen-

Large and midget impinger flasks

Photo courtesy U. S. Bureau of Mines



tration is recorded, the composition of the dust should, therefore, be specified.

Dust Counts

The most common procedure for the evaluation of a dust concentration is to make a "dust count"—that is, to determine the number of particles per unit volume of air in which the dust is suspended. With the exception of certain sampling instruments and methods, this ordinarily involves two major operations; namely, the sampling for dust in the field and the microscopic work, usually done in the laboratory. In some instruments the sampling device has been combined with a microscopic arrangement and calibrated in such a manner that almost instantaneous readings can be made. Such instruments usually handle exceedingly small air volumes, termed "grab" samples. The effect on the final evaluation of the dust exposure from such small samples will be considered later.

In order to discuss the outstanding characteristics of various dust appraisal instruments and the manner in which these characteristics may affect the dust counts, a few words will be devoted to a description of some of these devices in connection with a discussion of the various methods of evaluation.

Sampling

The Impinger—The best known dust sampling instrument in this country is undoubtedly the Greenburg-Smith impinger [see A New Instrument for Sampling Aerial Dust, by L. Greenburg and G. W. Smith, U. S. Bureau of Mines R. I. 2392, 1922].

In its simplest form this sampling device is composed of a glass tube, which is drawn into a fine nozzle at one end and inserted through a rubber stopper into a cylindrical flask containing a sampling liquid. The tube is adjusted so that its nozzle extends to within 5 mm of the bottom of the flask, while the air inlet end protrudes through the rubber stopper. A suction connection is provided at the top of the flask.

When the instrument is connected to a source of suction, the dust laden air to be sampled is drawn in through the tube, impinges against the bottom of the flask and bubbles through the sampling liquid on its way out. The dust is thus separated from the air and caught in the liquid, which usually consists of distilled water. Frequently the sampling liquid is composed of distilled water with 25 per cent ethyl or propyl alcohol. It is common practice to use 75 cc of liquid in the flask and the air flow through the instrument is controlled at 1 cfm.

Photo courtesy U. S. Bureau of Mines

Filling a dust counting cell

Counting Cells—For evaluation of impinger samples, a small portion of the sampling liquid containing the dust is put into a dust counting cell and examined under the microscope. The cell covered with a glass slide is a shallow glass chamber containing the liquid with the dust particles to be counted.

A variety of cells have been used for this purpose; the Sedgwick-Rafter and the Hatch cells are the best known. [See the Determination and Control of Industrial Dust, by J. J. Bloomfield and J. M. Dalla Valle, U. S. Public Health Service bulletin 217, 1935; and Industrial Dust, by Philip Drinker and Theodore Hatch, McGraw-Hill Book Co., respectively.]

The former, which has a depth of 1 mm, has been used extensively by the U. S. Public Health Service. The Hatch cell is only 0.25 mm deep and consequently requires a shorter settling period than the former, which is an advantage with respect to speed of analyses. Another advantage of the shallow cell is that heavy concentrations can be counted with less dilution. On the other hand, a smaller sample of the liquid is under observation in a shallow cell, involving a greater calibration factor in the final calculation, the effect of which will be discussed below. It is probable, however, that the effects of these two conditions balance each other, and that this is the reason why comparative studies of dust counts obtained with cells of varying depths show no significant difference.

Ohlheiser and Lawrence have described the use of a 0.1 mm deep blood counting cell for dust quantification, and indicated some of its advantages over other types. [See Dust Counting—a Simplified Technique, Journal of Industrial Hygiene and Toxicology, Vol. 22, No. 10, December, 1940.] Personally I feel that the ruled cell surface referred to by the authors is its most desirable feature. In the cleaning of a dust counting cell preparatory to its filling for the dust counting procedure it is almost impossible to clean the entire area. It is therefore, desirable to pick a few comparatively clean sections of the cell while it is still empty and be able to locate them again after the cell has been filled, in order to select these sections for the microscopic fields to be observed. With a ruled bottom, as in the case of the

blood counting cell, this is relatively easy, whereas it is much more difficult with the Sedgwick-Rafter and the Hatch cells with no points of reference available.

In the counting of dust particles in the cell, the U. S. Public Health Service is using the following microscopic setup: A disk on which a large square with 100 subdivisions have been ruled is inserted into the microscopic eye piece. The microscope is fitted with an Abbé condenser (light field), a 7.5 x ocular and a 16 mm objective. The tube length is adjusted so that the side of the large square of the eye piece measures 1 mm as observed by means of a stage micrometer. On this basis and with a 1 mm deep cell, the volume of the liquid represented by the above square is 0.001 cc, or 1000 are needed to get 1 cc. It is common practice to count only ¼ of the field, but to obtain an average of such a value, counting of two cells and five fields in each cell is usually done. Thus to obtain the final count per cubic foot of air sampled after the average ¼ field value is known, it must be multiplied by four, by one thousand and by the number of cubic centimeters in the sampling liquid and then divided by the number of cubic feet of the air sample taken.

If we let the average count per ¼ field be represented by C, the mathematical expression may be written as:

$$\text{Final count} = \frac{C \times 4000 \times \text{cc}}{\text{cu ft}}$$

The (4000 x cc/cu ft) might be called a factor by which the dust count must be multiplied in order to obtain the final dust value. In order to see how this factor affects various dust counts, let us assume a specific case of, say, a 15 min sample (i.e., 15 cu ft) and with 75 cc in the impinger flask. The factor then becomes (4000 x 75/15) = 20,000.

In this particular case let us also assume a dust concentration of 10 million particles per cubic foot. In order to get this concentration, the ¼ field count must equal 500. This concentration is too heavy to count, however, so the sample will have to be diluted, say 10 times. This means a concentration in the ¼ microscopic field of about 50 particles and the factor will have to be multiplied by 10, i.e., instead of 20,000 it becomes 200,000.

Now let us see how this factor may affect our final error. Anyone who is familiar with dust counting, I am sure, will agree that it is very easy to miss five particles out of 50 in the microscopic field, or to include that many twice, particularly in light field counting. Now, applying the above factor, such an error results in plus or minus 1,000,000 particles per cubic foot in the final count. As the concentration goes up, the greater must be the dilution and the multiplication factor increases accordingly. On the above basis and with a dilution of 20 times, it can therefore readily be seen that an error of only two or three particles in the average ¼ microscopic field will produce a final error of one million.

In a technique used extensively by other investigators, the unit area of the microscopic field employed as reference in the final calculation is considerably smaller than the ¼ square of the U. S. Public Health Service method described above, with the result that a much greater calibration factor must, therefore, be applied. A setup of this type used by the author consisting of a 7 x eye piece, a 16 mm objective with a 160 mm tube length and a ¼ mm deep Hatch cell for light field counting, calls for a calibration factor of 6.3×10^5 to be applied to a particular area in the ocular micrometer. At first it might seem that such a large calibration factor would increase the final error considerably. The fact of the matter is, that although this small area is represented in the final calculation, a large area has been counted by covering a number of small squares and an average count per square obtained, thus insuring that the percentage of error is no greater with this method than with the standard procedure of the USPHS previously described.

As mentioned above, the factor influencing the absolute error becomes greater with high concentrations necessitating excessive dilutions. This is an item of importance in dark field counting, which includes a much greater size range than the light field technique, due to the lower limit of visibility produced by the dark field condenser. It is not at all unusual to encounter dark field counts 10 times higher and sometimes more than the light field count on the same samples. This calls for considerable dilutions with a rise in the multiplication factor and a corresponding increase in error of the final dust count.

[Future articles by Mr. Bernz will cover other sampling and dust counting methods, as well as the choice of instruments, methods of sampling and evaluation.]

SUBCONTRACTING FOR WAR PRODUCTION

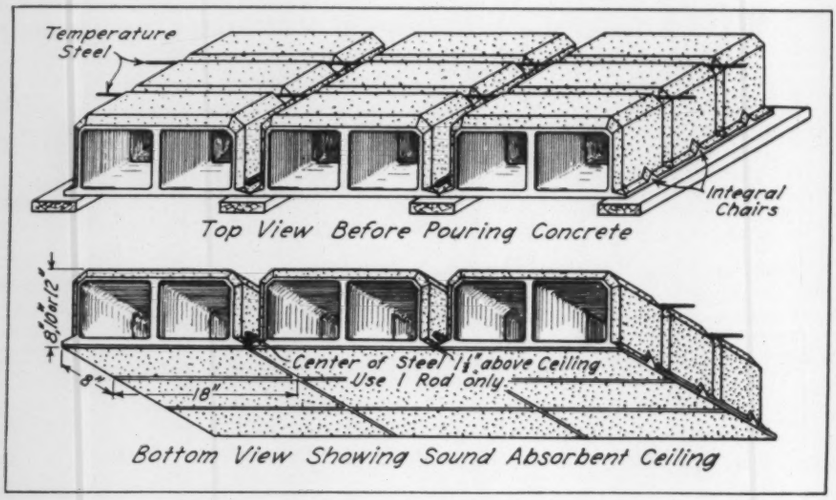
Subcontracting for Defense: A Study Prepared in the Interest of Stabilizing Employment (a report issued by the policyholders service bureau of the Metropolitan Life Insurance Co., 1 Madison Ave., New York City) outlines the methods followed by 28 companies that have been particularly successful in meeting the problems of prime contracting or subcontracting. It includes a section on obtaining prime contracts for various types of supplies and equipment required by the government, and describes sources of information on governmental requirements and on procurement setup and procedure. It discusses the administration of and responsibility for subcontracting in the prime contractor's organization, and steps commonly followed in selecting and scheduling work to be farmed out. The report also shows a variety of sources which primary contractors use to locate and contact subcontractors, and methods adopted for appraising their facilities and skill.

The procedure followed in obtaining a subcontract is thoroughly covered in the report by a presentation of details of the methods used by successful subcontractors. Some of the other points covered are: the assistance typically given by the prime contractor to the subcontractor, production control procedures for both the prime contractor and the subcontractor, and the basis for pricing subcontract work.

A copy of this report is available from Metropolitan Life.

Hollow Floors for Radiant Heating

F. E. Markus Gives Brief Description of New Type of Floor Construction Which Incorporates an Integral Duct System



IN connection with research on hospital planning, where part of the problem consisted of developing a simple means of obtaining the advantages of radiant heat without high initial cost, a new type of fireproof floor construction (which is being patented) was developed which integrally incorporates a modular duct system. Certain features tend to bring the cost of this floor construction down to that of second class construction; namely, its lightness and consequent saving in reinforcing steel, self-spacing of units, self-spacing and aligning of reinforcing steel without the use of chairs, elimination of plaster ceiling, etc. There is reason to believe that considerable applications other than in hospitals may develop.

The construction also lends itself for slabs on fill where radiant heating would be very desirable as, for example, in industrial buildings where high ceilings and large areas of glass are usually employed. Fire stations, airplane hangars and other buildings where large doors are wide open for prolonged periods are also logical possibilities for radiant heating.

Strangely enough, in the first installation the choice of this floor system was made for reasons not originally contemplated; namely, a need for a light fireproof floor because of the limitation of existing foundations and the desire to conceal all sprinkler pipes. The sprinkler mains were run in the center of each structural bay at the neutral axis and at 90 deg to the floor ducts with one-head sprinkler runouts, right and left, concealed in the ducts. The light weight aggregate blocks are easily cut around pipes, access panels, etc.

In the use of the ducts for radiant heating there are several optional methods, depending upon conditions. All the available ducts may be used for hot air as is usually necessary in the case of the slab on fill, to keep the floor temperature low enough for comfort. Or in multi-story buildings where radiation is effected on both ceiling and floor every second or third duct can be used and the remaining voids left for use as pipe chases.

Main supply and return ducts for tying into the floor system are constructed in the usual manner and run at right angles to the floor ducts. In some cases the supply and return ducts can best be run in the furred corridor ceiling. In this arrangement the special outside end blocks become in effect 180 deg elbows. Another method is to place the supply duct only in the furred corridor ceiling, collecting all floor ducts into a return main at the outside wall, either furred on the ceiling below or inside the spandrel above.

SUMMARY—Research work by Markus & Nocka, Boston architects, on hospital construction has developed a new low cost, hollow fireproof floor system incorporating an economical method of circulating hot air through the floor for radiant heating. Applications to industrial and other building types appear equally feasible. . . . . The construction also lends itself for slabs on fill where radiant heating would be very desirable as, for example, in industrial buildings where high ceilings and large areas of glass are usually employed. Fire stations, airplane hangars and other buildings where large doors are wide open for prolonged periods are also logical possibilities for application of radiant heating

TREATMENT OF WATER FOR AIR CONDITIONING

We have found that when the proper chromate concentrations are carried in both air washer and cooling tower waters, and when the pH value of the water has been adjusted to 8.0 to 9.0, that it is unnecessary to change the water in various circuits for much longer periods of time than when no chromate treatment is used. This is due to the fact that the chromates are oxidizing mediums and destroy a great number of organisms ordinarily found in recirculated water.

Quite often we have found that the use of alkaline or neutral pentachlorophenols or pentachlorophenates has been very effective in killing algae, and thereby cutting down unpleasant odors from the recirculated water.

The hardness or quality of the make up water is one of the most important factors in governing time of water changes, especially in cooling towers or evaporative condensers.—C. M. STERNE, chief engineer, Metropolitan Refining Co., Inc.

Increased attendance as a result of air conditioning is reported by the First Methodist church, of Birmingham, Ala. A refrigeration system with ice storage was chosen to meet the needs of the building. During the week 35 tons of ice is made and dropped by gravity into a tank where it is stored until used.

LUBRICANTS FOR BALL BEARINGS

APPRECIATING the problems faced by users in obtaining suitable greases for relubricating ball bearings, the Annular Bearing Engineers' Committee, 60 E. 42nd St., New York, N. Y., has been undertaking a research program from a chemical and mechanical standpoint. For years there were many greases available, but these were chiefly of lime soap bases which had limitations.

The standards which follow have been developed from practical experience and careful analysis by the committee, but it may become desirable to revise these occasionally to keep abreast of developments in the lubricant field. Some lubricants which conform to these standards may not be suitable for all applications; some greases which do not conform may sometimes be satisfactory. For all applications, the user is advised to obtain the approval of the grease manufacturers.

The ABEC has developed a grease testing machine for determining the physical characteristics of greases and a number of the properties called for in these standards are determined with this machine.

ABEC I—Type of grease recommended for speeds and temperatures as indicated in guide for relubricating ball bearings

Greases shall be free from dirt, abrasive matter, fillers, excessive amounts of moisture and free acid or free alkali.

Nature of soap: Soda or soda lime: maximum lime soap 5 per cent of total weight of grease; uncombined lime 0.10 per cent max.

Worked penetration, ASTM: 190 min.

Running torque, ABEC test: 60-300 gm cm.

Leakage: Through plate seal: 5 per cent max. Left in bearing: 75 per cent min.

Oxidation: See details below.

ABEC II—General purpose greases, suitable for grease gun applications, for modern speeds and temperatures as indicated in guide for relubricating ball bearings

Greases shall be free from dirt, abrasive matter, fillers, excessive amounts of moisture and free acid or free alkali.

Nature of soap: Soda or soda lime: maximum lime soap 5 per cent of total weight of grease; uncombined lime 0.10 per cent max.

Worked penetration, ASTM: 260 min.

Running torque, ABEC test: 60-450 gm cm.

Leakage: Through plate seal: 20 per cent max. Left in bearing: 75 per cent min.

Oxidation: See details below.

Oxidation: Greases shall show no evidence of deterioration following 18 months storage in bearings in individual sealed boxes or packages as indicated by oil leakage, hardening, or gum formation of the grease, or by loss of free turning by hand.

Alternatively, the grease shall show no change in consistency, drop point, or neutralization within the limits defined below,* nor more than 5 psi drop in oxygen pressure following a 100 hr run in Norma-Hoffmann oxidation bomb at 210 F and 110 psi initial oxygen pressure, using a 20 gram sample on standard glass sample dishes. When tested under the same conditions with the addition of a piece of sheet copper partially immersed in the sample, there shall be no evidence of stain or corrosion of the copper strip, nor any evidence of physical change in the grease after 6 hr of exposure.

Greases for Relubrication of Ball Bearings

Operating Temperature Range, F	Speed Factor (Bearing Bore in MM x RPM of Shaft)			
	Up to 75,000	75,000 to 150,000	150,000 to 300,000	300,000 to 450,000
−50 to +125	No Recommendation	No Recommendation	No Recommendation	No Recommendation
−10 to +125	ABEC-II†	ABEC-I	ABEC-I	No Recommendation
32 to 150	ABEC-II	ABEC-I	ABEC-I	No Recommendation
60 to 200	ABEC-II	ABEC-I	No Recommendation	No Recommendation
Over 200	No Recommendation	No Recommendation	No Recommendation	No Recommendation

For excessive moisture conditions, a water repellent grease may be required.
†ABEC-I may be preferred for some applications.

*Consistency ASTM penetration or equivalent and drop point Shell Ubbelohde shall not increase or decrease more than 10 per cent.

*Neutralization numbers made on grease samples before and after 100 hr accelerated oxidation, or 18 months' storage test, must not show a total change of more than the equivalent of 10 mg of KOH per gram of grease, nor shall the neutralization number following 100 hr oxidation show acidity exceeding the equivalent of 5 mg of KOH per gram of grease.

The ABEC Grease Testing Machine Test Procedure

1) Calcium soap greases shall be tested with an oil bath temperature maintained at 80-85 F, and at 150 F.

2) Sodium soap greases shall be tested with an oil bath temperature maintained at 80-85 F, at 150 F, and at 220 F.

3) The test bearing shall be a Conrad Type, single shielded, SAE 204, assembled into the test fixture with the shield at the bottom. These bearings can be purchased from any of the ball bearing manufacturers and should be specified for the ABEC machine.

4) The bearing seal on the motor shaft extension should be checked periodically with a dial indicator and adjusted, if necessary, to run true within 0.0003 in. total indicator reading on the bearing seat and the shoulder in radial and axial directions, respectively.

5) The bearings, which shall be furnished coated with a rust preventive, should be prepared for test by washing same in mineral spirits which conforms with ASTM specification D-235-39, after which they should be dried out so that there is no condensate present. The bear-

ing is to be packed with a quantity of grease equivalent to 60 per cent of the air space volume of the test bearing, this grease to be put into the bearing so that it is level full with the top of the bearing. The bearing is then to be rotated by hand to distribute the grease over the contacting surfaces of the bearing.

6) The test at each temperature shall be for 20 min duration.

7) Tests shall be conducted with one sample and shall be checked between tests to determine amount of leakage; after determining percentage of leakage, the grease which has been thrown out or leaked through shall be returned to the bearing for subsequent tests. All grease which leaks through the bearing shall be collected and weighed, and the amount of grease left in the bearing shall be determined by the difference in weight.

8) Between successive runs, the temperature shall be raised at the rate of 10 to 12 F per min with bearing at rest.

9) The torque shall be recorded at the end of 0-1-2-3-4-5-6-7-8-9-10-15 and 20 min.

10) Observations of separation, change in structure, change in consistency, leakage, and aeration shall be made during the tests.

(Grease specification blanks may be obtained from any manufacturer of ball bearings or from the secretary of the Annular Bearing Engineers' Committee, 60 E. 42nd St., New York, N. Y.)

Lubrication of Anti-Friction Bearings with Oil

The friction torque in a ball bearing lubricated with oil consists essentially of two components. One of these is a function of the bearing design and the load imposed on the bearing and the other is a function of the viscosity and quantity of the oil and the speed of the bearing.

It has been found that the friction torque in a bearing is lowest with a very small quantity of oil, just sufficient to form a thin film over the contacting surfaces, and that the friction will increase with greater quantity and with higher viscosity of the oil. With more oil than just enough to make a film, the friction torque will also increase with the speed.

The energy loss in a bearing is proportional to the product of torque and speed, and this energy loss will be dissipated as heat and cause a rise in the temperature of the bearing and its housing. This temperature rise will be checked by radiation, convection and conduction of the heat generated to an extent depending upon the construction of the housing and the influence of the surrounding atmosphere. The rise in temperature, due to operation of the bearing, will result in a decrease in viscosity of the oil and, therefore, a decrease in friction torque compared with the friction of starting, but soon a balanced condition will be reached.

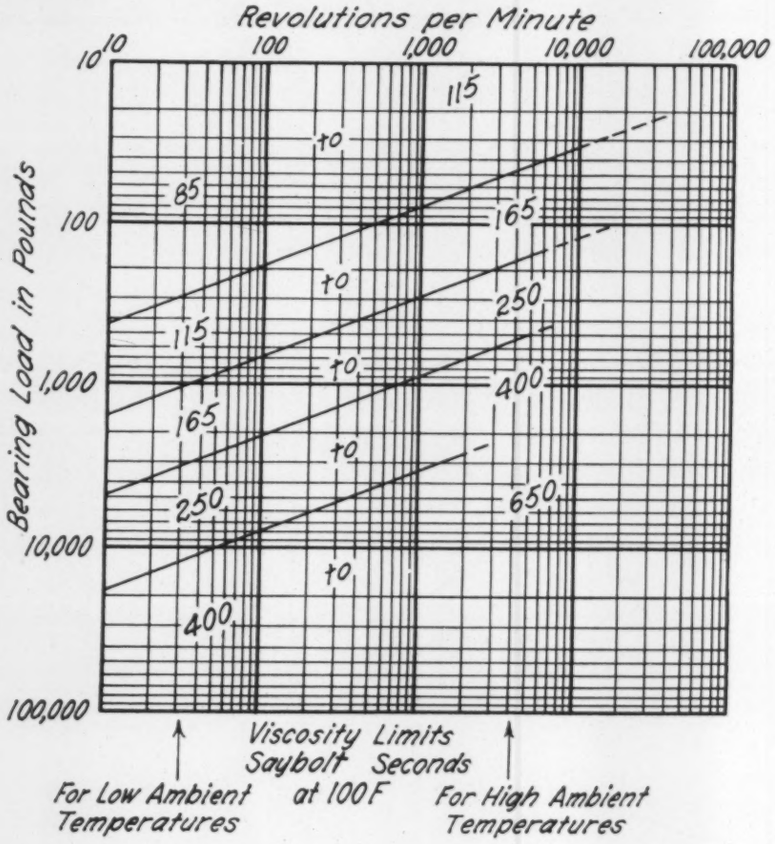
With so many factors influencing the friction torque, energy loss and temperature rise in a bearing lubricated with oil, it is evidently not possible to give definite recommendations for selection of oil for all bearing applications, but two general considerations are dominant:

1) The desire to reduce friction to a minimum, which requires a small quantity of oil of low viscosity.

2) The desire to maintain lubrication safely without much regard for friction losses, which results in using larger quantities of oil and usually of somewhat greater viscosity in order to reduce losses from evaporation or leakage.

This second condition is most frequently met and in view of the broad outline of lubrication with oil made above, the accompanying chart has been made up for selection of viscosities of oil for various operating conditions.

The operating speeds (rpm) are given on one coordinate of the diagram and the bearing loads in pounds on the other, both to a logarithmic scale. The lines intersecting the coordinates indicate viscosity groups for oils that are preferred for these loads and speeds. When ambient temperatures are low the lower viscosity ranges should be used and with high operating temperatures the higher viscosities should be selected.



When bearings have to operate in a wide range of temperatures, an oil that has the least changes with change in temperature, i.e., an oil with high viscosity index, should be selected.

In the great majority of applications pure mineral oils are most satisfactory, but they should, of course, be free from contamination that may cause wear in the bearing, and they should show high resistance to oxidation, gumming and to deterioration by evaporation of light distillates and they must not cause corrosion of any parts of the bearing during standing or operation.

It is self-evident that for very low starting temperatures an oil must be selected that has sufficiently low pour point, so that the bearing will not be locked by oil frozen solid.

In special applications, various compounded oils may be preferred, and in such cases the recommendation of the lubricant manufacturer should be obtained.

Heating-Piping-Air Conditioning

AMERICAN SOCIETY of HEATING and VENTILATING ENGINEERS

Journal Section

At the Last Minute

A spring meeting of the Council early in April is planned by Pres. E. O. Eastwood.

• • •

Society Officers will visit several Chapters in April. President Eastwood's schedule is Los Angeles, Kansas City, St. Louis and Pittsburgh; and Vice-Pres. M. F. Blankin will go to Detroit and Grand Rapids.

• • •

Chairman A. J. Offner of the Guide Publication Committee has called a meeting at Philadelphia Engineers Club for March 14. All members of the Society are invited to send suggestions.

• • •

Chairman W. A. Russell of the Membership Committee has proposed an interesting plan to Chapters to increase membership in 1942.

• • •

Coming in April

Observed Performance of Some Experimental Chimneys, by Richard S. Dill, Paul R. Achenbach and Jesse T. Duck.

The Effect of Attic Fan Operation on the Cooling of a Structure, by W. A. Hinton and Albert F. Poor.

Concluding Installment of Proceedings of the 48th Annual Meeting

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Factors Influencing the Heat Output of Radiators

By A. C. Davis*, W. M. Sawdon** and David Dropkin†

SUMMARY—An analysis is given of the factors which affect the heat output of radiators. It is clearly shown that the conditions of a test room can be varied very materially without affecting the rating which a radiator would be given when that rating is based on the maintenance of a defined temperature at a fixed point in a room. This temperature is specified to be measured by a mercury thermometer, and it is interesting to note that the temperature distribution in the room can be varied as widely as shown in Fig. 7 and yet result in the same radiator rating

Introduction

THE present ASHVE radiator test code (1927) in its description of the test room specifies that: "The test room shall be 12x15 ft in floor area and have a ceiling height of 9 ft with an allowable tolerance of plus or minus 10 per cent in any dimension. The walls and ceiling shall have a smooth, close surface and be painted flat gray in color. A window not larger than 16 sq ft will be permitted in the test room, but the window shall be shielded from direct rays of the radiator."[1]

It is evident from this description that a certain amount of freedom is permitted in the construction of the test room, the use of windows and the size of radiator. The main objective of the tests hereinafter described was to determine the effect of test room insulation, the number and arrangement of windows, and the size of radiator on the performance of household radiators.

Description of Laboratory and Apparatus

The Constant Temperature Room

The test room, in which each radiator when under test was located, was erected within the constant temperature room of newly constructed heat transfer laboratory shown in Figs. 1 and 2. This laboratory consists of a constant temperature room, a cooler room, and an instrument room. The constant temperature room is 26 ft x 29 ft with a ceiling height of 12 ft. The cooler room is 7 ft 7 in. x 14 ft with a 12 ft 6 in. ceiling. The instrument room is 10 ft x 34 ft with a 12 ft ceiling.

The constant temperature room and the cooler room have a common wall, 12 ft x 14 ft; while the instrument room has a side common to both the constant temperature room and the cooler room. The constant temperature room has a *superfreezer* door, 4 ft 6 in. x 6 ft and two *plug doors*, 2 ft x 2 ft each. Pipes, wires, etc., leading to the instrument room are introduced through the plug doors. The cooler room has a 2 ft 6 in. x 6 ft *superfreezer* door leading to the instrument room. All the walls of both the constant temperature room and the cooler room are insulated with 8 in. of cork applied in two layers. The floors have a base of 4 in. concrete upon which is placed 8 in. of cork and 3 in. of reinforced concrete. On the north side, the east end, and 11 ft of the south side of the constant temperature room the insulation rests against the brick walls of the building with 1 in. to 1½ in. of plaster between the walls and the cork. The windows are covered with masonite resting against the sash. The space between the masonite and the cork blocks is filled with ground cork. The ceiling of this room consists of a suspended steel deck, above which is 8 in. of cork with 1 in. of cement plaster on top of the cork. On the south side of the cooler room the insulation is placed against a 6 in.

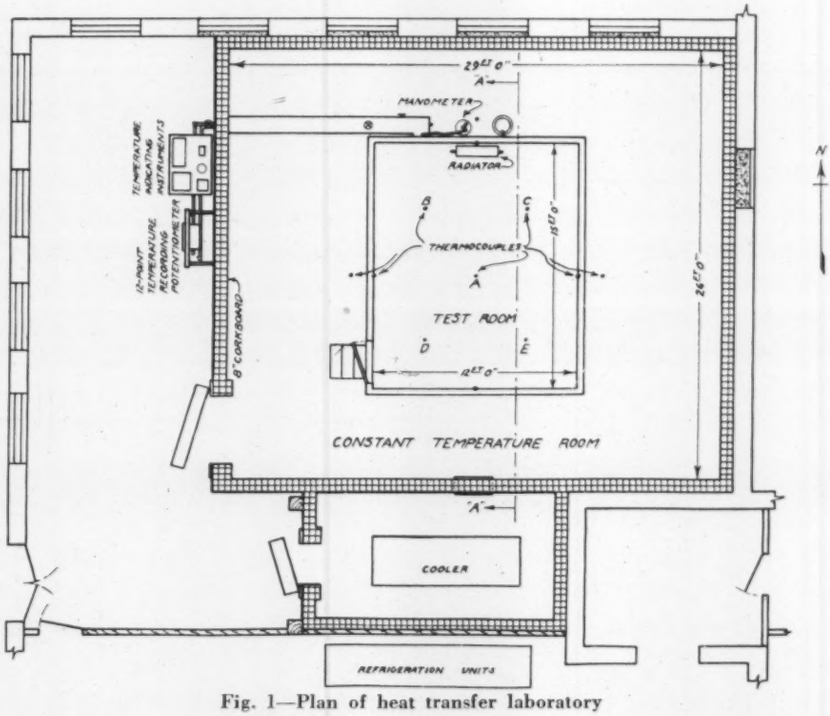


Fig. 1—Plan of heat transfer laboratory

*Professor and Head of Department of Experimental Engineering, Cornell University.

**Professor of Experimental Engineering, Cornell University. MEMBER of ASHVE.

†Instructor of Experimental Engineering, and Westinghouse Research Associate, Cornell University.

[1]The Condensation Method for the Testing of Direct Radiators, (ASHVE TRANSACTIONS, Vol. 33, 1927, p. 19.)

Presented at the 48th Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Philadelphia, Pa., January, 1942.

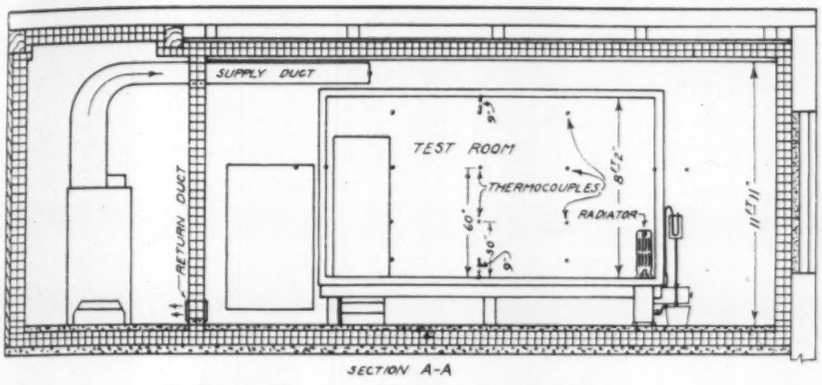


Fig. 2—Elevation of heat transfer laboratory

double-sided wooden partition. The inner surfaces of the walls of both the constant temperature room and the cooler room are plastered with asphalt emulsion and painted with a white cold storage paint. The walls, where exposed to the instrument room, are plastered on the outside with cement.

The cooling equipment has a capacity of 15 tons of refrigeration and consists of a 4 in. x 4 in. ammonia compressor, a 5¾ in. x 4 in. booster compressor, a 16 in. sixteen-pass condenser, a water cooled intercooler, a liquid and gas cooler, a liquid receiver, an oil separator, pressure gages, controls, etc. This equipment is located just outside the air cooler room. Within the cooler room is located the accumulator with float control and the cooler with its fan and motor.

The air which is supplied to the constant temperature room is cooled in the cooler room and then blown into the constant temperature room at the required temperature. This method of air cooling minimizes radiant heat losses from objects within the constant temperature room since the coldest object within the room is the air duct supplying the colder air. This duct is only slightly colder than the air of the room. This arrangement makes it possible to maintain a uniform temperature throughout the room by controlling the air distribution. During the radiator tests thus far conducted, the inlet air temperature has been about 6 F lower than the average air temperature within the constant temperature room.

The air temperature in this room is thermostatically controlled and the thermostat can be set to maintain any desired temperature between minus 50 F and plus 100 F. A carefully designed distributing system discharges the air near the ceiling in such a manner that at no time during a test was the difference in temperature, at the same level in different parts of the room, more than 1 F. The return opening is located near the floor.

Equipment and Method of Test

The radiator test room was built to conform, in so far as it was possible, with the ASHVE test code specifications. The construction of the room was in sections so that it could be easily taken apart. The room as used for the tests hereinafter described is shown in Figs. 1 and 2. It was 15 ft long, 12 ft wide and 8 ft 2 in. high. Each section, except those used for the floor, consisted of a wooden frame made up of 1 in. x 4 in. studs placed on 16-in. centers. The frame was covered with ⅛ in. thick hard pressed masonite board. The floor was constructed in the same manner as the walls and ceiling except that 2 in. x 4 in. joists and ¼ in. thick masonite boards were used. A small section of the floor which supported the radiator was made of ⅜ in. thick wood flooring in order to provide extra strength and rigidity. The masonite wall back of the radiator was covered with ½ in. plaster board. The entire inside surface of the test room was painted with flat gray paint. To provide easy access to the room a standard 1⅜ in. wooden door was located at the southwest corner of the room. This door, however, was never opened when an experiment was in progress.

Thirty copper-constantan thermocouples and five thermometers were installed to measure the air temperatures of the constant temperature room as well as the air and surface temperatures of the walls, floor, and ceiling of the test room. Air temperatures of the test room were measured at 9 in., 30 in., and 60 in. above the test room floor and at 9 in. below the ceiling, at five different stations (Figs. 1 and 2). The wall temperatures were measured 5 ft above floor level, while the floor and ceiling temperatures were measured at station *A*.

A 12-point recorder was used to record the air temperatures within the test room at the stations *A*, *B*, and *E*. The remaining thermocouples were connected to a semi-precision portable potentiometer and a complete set of readings was taken every 15 min.

In order to insure dry steam entering the radiator, the pipe line supplying the steam was heavily insulated; three continuous bleeders were provided, the last one being only about two feet away from the radiator. The steam entering the radiator was always kept in a slightly superheated state. For all experiments reported in this paper the absolute pressure of the steam entering the radiator was kept at 31.9 in. of mercury. A well insulated condensate collector was attached at the outlet end of the radiator—thus completing a two-pipe system. During all test runs, the water level in the collector was kept high so as to minimize con-

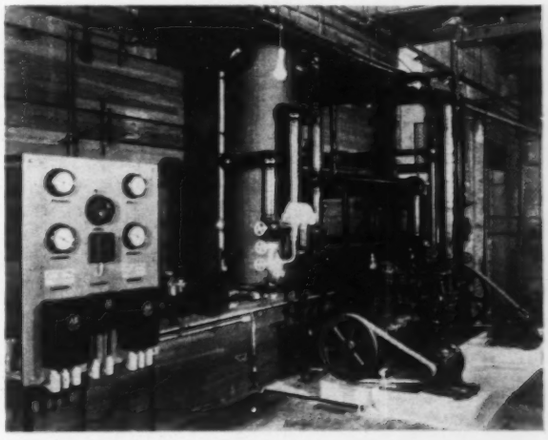


Fig. 3—Ammonia compressors used to provide cooling for the constant temperature room

Table 1*a*—Results of Tests When the Number of Sections in a Radiator Was Varied

Number of Sections in Radiator	Total E.D.R.	E.D.R. Per Section	Inside Surface Temperatures of Test Room, Deg F						Per Cent Deviation in Radiator Output per Section
			North Wall	West Wall	South Wall	East Wall	Floor	Ceiling	
12	29.99	2.50	89.6	62.1	62.1	62.1	60.6	63.9	.....
40	105.81	2.65	80.5	44.4	42.8	46.6	35.0	49.2	6.0

densation. The pipe connecting the radiator to the collector was only about 6 in. in length and well insulated. The arrangement of all connections to the radiator was such that the condensation within piping was negligible as compared to the total condensation within the radiator. The condensate was drained continuously into pails. The surface of the water in the pails was covered with a layer of heavy oil to prevent a loss of condensate by evaporation. The condensate was weighed every 30 min on a calibrated scale which read directly to 0.01 of a pound. No test run was accepted unless the weight at each 30-min interval checked within less than 1 per cent. For all tests hereinafter described the desired temperature in the test room was maintained by controlling the temperature of the constant temperature room.

Results of Tests

Effect of Size of Radiator

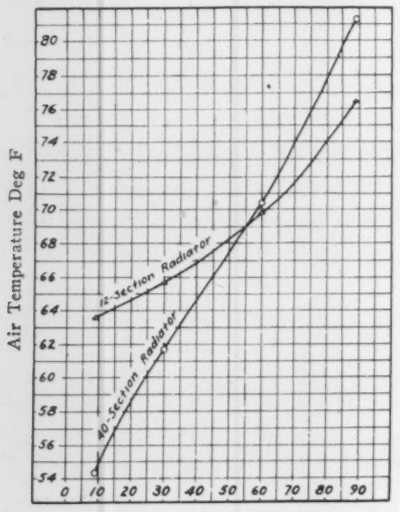
The present radiator test code does not specify the approximate size of radiator to be tested in the test room. It is obvious that the output per section of a large radiator will be higher than that of a small one when the same temperature at a given level is maintained in the test room. In order to determine the effects of size on radiator performance, the following experiment was made.

A 40-section, 5-tube, 26-in. small tube radiator, with sections on 1½-in. centers, was installed in the test room and its output per section determined. The size of the radiator was then reduced to 12 sections and the output per section was again determined. During both tests the temperature at the center of the test room at the 5-ft level was kept constant at 70 F.

Table 1*a* and Fig. 4 show the results of this experiment. From this table it may be seen that the larger radiator gave off 6 per cent more heat per section than the smaller one. This can be attributed to the fact that the larger radiator lost more heat per section by both convection and radiation.

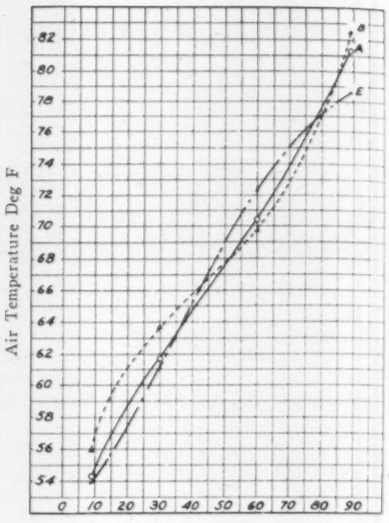
Fig. 4 shows the temperature gradients at the center of the test room for the two sizes of radiator. These curves show that the air temperature below the 5-ft level was lower for the larger radiator. This lower air temperature resulted in greater heat loss per section by convection.

The heat loss per section by direct radiation was greater for the larger radiator as shown by the results given in Table 1*a*. Here it is shown that the surface temperatures of walls, floor, and ceiling were much lower when the 40-section radiator was tested than when the 12-section radiator was tested. The law of heat transfer by radiation states that the net heat transfer is directly proportional to the difference in the fourth power of the absolute temperatures of the hot body and the cold body. The hot body, that is the radiator, was at the same temperature for both the 40- and the 12-section radiator tests while the cold body temperatures were different. It is obvious then in the light of these facts that the larger radiator lost more heat per section by radiation.



Height above floor in inches

Fig. 4 — Comparison of temperature gradients at center of test room for 40- and 12-section radiators



Height above floor in inches

Fig. 5—Temperature gradients at Stations A, B, and E for the 40 section radiator

During the computation of the results of radiator tests, a question was raised as to whether the temperature at the center of the test room represented the average temperature at a given level. The plot, in Fig. 5, clearly shows that for the test room used, the temperatures at the center of the room were approximately an average of the temperatures at a given level.

Effect of Test Room Insulation

In order to find the effect of insulation on both radiator output and temperature gradient within the test room, two series of tests were undertaken. For both series a 12-section, 5-tube, 26-in. radiator with sections on 1½ in. centers was used.

In the first series the temperature at the 5-ft level, in the center of the test room, was kept constant at 70 F. In the first test of this series the test room had no extra insulation, it being of the same construction as when the tests to determine the effects of size of radiator were made. In the second test the ceiling was insulated; in the third test, ceiling and floor were insulated; in the fourth test, ceiling, floor and the east wall were insulated; in the fifth test, ceiling, floor, east, and south walls were insulated; and finally ceiling, floor, east, south, and west

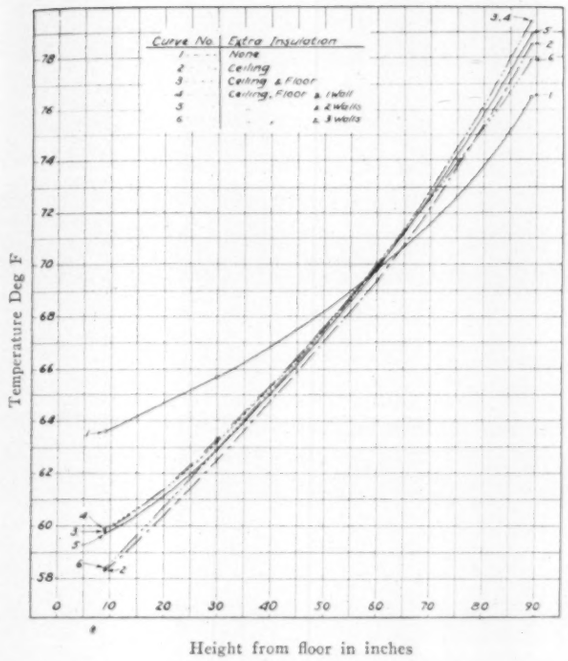

Curve No. | Extra Insulation
1 None
2 Ceiling
3 Ceiling & Floor
4 Ceiling, Floor & 1 Wall
5 " " & 2 Walls
6 " " & 3 Walls
Temperature Deg F
Height from floor in inches

Fig. 6—Temperature gradients at center of test room with different insulation conditions. Temperatures kept constant at the 60 in. level

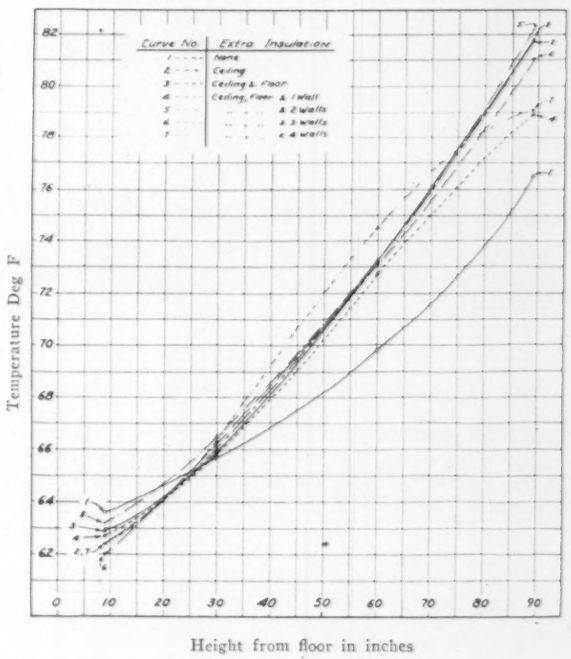

Curve No. | Extra Insulation
1 None
2 Ceiling
3 Ceiling & Floor
4 Ceiling, Floor & 1 Wall
5 " " & 2 Walls
6 " " & 3 Walls
7 " " & 4 Walls
Temperature Deg F
Height from floor in inches

Fig. 7—Temperature gradients at center of test room with different insulation conditions. Temperatures kept constant at the 30 in. level

walls were insulated. In all of the above-mentioned tests the extra insulation used was 3 in. of mineral wool and ¼-in. plywood board.

The second series of tests was performed with the same variation of test room insulation as the first series. In this second series of tests a temperature of 66 F was maintained at the 30-in. level. An additional test was made with the ceiling, floor, east, south, west, and north walls insulated. In this last test the north wall, that is the wall back of the radiator, was insulated so that its calculated value of overall heat transfer coefficient was 0.24. This value corresponds closely to values commonly assumed for uninsulated homes.

The temperature gradients for the first series of tests, that is when the temperature at the center of the test room at the 5-ft level was kept constant at 70 F, are shown in Fig. 6. It may be seen from these curves that, when no extra insulation was used, the difference in temperature between floor and ceiling was less than under the other conditions of insulation. In general, when insulation was used, the temperature gradient remained approximately the same regardless of whether only the ceiling was insulated or the ceiling, floor, and the three walls were insulated. The surface temperatures, however, varied with the amount of insulation used. (See Table 1*b*.)

The heat loss through any section of the test room structure by conduction is equal to the heat transfer between the air and the inside surface of this structure. The surface transfer may be found by the following equation:

$$Q = A\, f_i\, (t - t_1)$$

in which

Q = rate of heat transfer, Btu per hour

A = area of surface, square feet

f_i = film coefficient, Btu per hour per square foot per degree Fahrenheit

t and t_1 = the temperatures of the inside air and the inside wall surface, respectively, degrees Fahrenheit

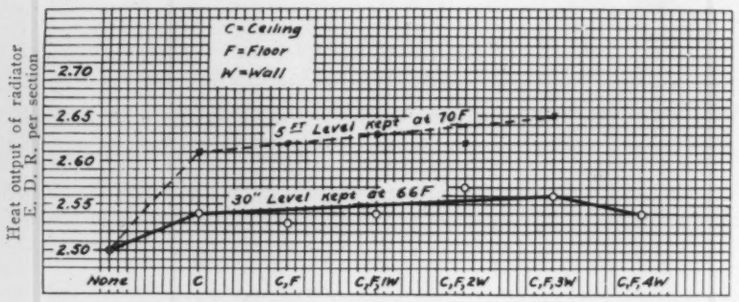
If a certain portion of the room is insulated, the inside surface temperature will increase. This will, in turn, reduce the amount of heat transferred from the air to this surface. For a given amount of heat to be transferred, it is obvious that the surface temperatures of the uninsulated portions of the room will have to be reduced in order to compensate for the smaller transfer of heat through the insulated sections.

As previously stated, heat loss from a radiator by convection depends on the temperature of the air which comes in contact with the radiator, if constant air velocity be assumed. When the ceiling of the test room was insulated, the temperature gradient became larger. When the temperature at the 5-ft level was kept constant, the temperatures below this level became lower when insulation was used. This means, then, that colder air came in contact with the radiator and thus a larger heat loss by convection occurred.

Table 1*b*—Effect of Insulation When the 5-Ft Level at Center of Test Room Was Kept Constant at 70 F

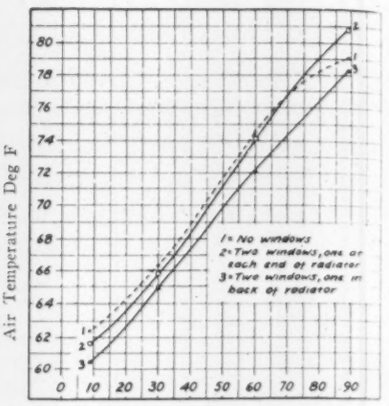
Number of Sections in Radiator	Total E.D.R.	E.D.R. Per Section	Inside Surface Temperatures of Test Room, Deg F						Parts of Test Room Insulated
			North Wall	West Wall	South Wall	East Wall	Floor	Ceiling	
12	29.99	2.50	89.6	62.1	62.1	62.1	60.6	63.9	None
	31.34	2.61	83.9	56.9	57.2	58.2	53.3	70.0	C
	31.44	2.62	85.0	56.7	56.4	56.8	60.3	70.7	C, F
	31.56	2.63	83.6	54.8	54.0	66.1	60.2	71.0	C, F, 1W
	31.48	2.62	81.6	51.5	65.5	65.4	58.7	69.7	C, F, 2W
	31.81	2.65	78.3	66.3	66.0	66.4	59.1	69.8	C, F, 3W

C = Ceiling.
F = Floor.
W = Wall.



Surfaces of test room having extra insulation

Fig. 8—Comparison of heat output of a radiator with different test room insulation conditions, when temperature was kept constant at 30-in. level, with that when temperature was kept constant at 5-ft level



Height above floor in inches

Fig. 9—Comparison of the temperature gradients at center of test room with and without windows

However, as shown in Fig. 7, when the air temperature was kept constant at the 30-in. level, a better control of the temperature of the air coming in contact with the radiator was obtained. In general, the larger portion of the total heat loss from a radiator is by convection. For this reason one would expect a smaller effect of room insulation on radiator output when the temperature is controlled at the 30-in. level as compared with that at the 5-ft level. The foregoing statement is substantiated by data shown in Figs. 6, 7, and 8. Fig. 8 shows a direct comparison, in units of equivalent direct radiation,[2] of the radiator output per section, when the temperature was kept constant at the 60-in. level, with the output per section when the temperature was kept constant at the 30-in. level.

[2]The unit of E.D.R. is 240 Btu per hour.

It should be observed that when the ceiling of the test room was insulated, the E.D.R. per section increased for both thermometer positions. In the case in which the 30-in. level was kept at constant temperature the increase was 1.6 per cent, while with the 5-ft level kept at constant temperature the increase was 4.4 per cent. The total increase of radiator output with the ceiling, the floor, and three walls insulated was 2.4 per cent for the 30-in. level and 6 per cent for the 60-in. level.

The curve in Fig. 8 shows that when the last wall was insulated (*i.e.* the one back of the radiator), the E.D.R. per section decreased. If the same amount of extra insulation had been placed on the wall back of the radiator as was placed on the other surfaces, the E.D.R. would have been the same as if no extra insulation had been used.

Table 1c—Effect of Insulation When the 30-In. Level at Center of Test Room Was Kept Constant at 66 F

Number of Sections in Radiator	Total E.D.R.	E.D.R. Per Section	Inside Surface Temperatures of Test Room, Deg F						Parts of Test Room Insulated
			North Wall	West Wall	South Wall	East Wall	Floor	Ceiling	
12	29.96	2.50	89.6	62.1	62.1	62.1	60.6	63.9	None
	30.52	2.54	90.0	62.1	62.1	62.8	58.4	74.5	C
	30.36	2.53	91.4	59.8	59.8	60.2	62.4	74.0	C, F
	30.46	2.54	89.9	57.4	56.6	68.0	61.3	73.5	C, F, 1W
	30.86	2.57	85.5	56.2	69.6	69.6	62.9	73.6	C, F, 2W
	30.72	2.56	81.1	69.2	68.9	69.6	62.5	72.8	C, F, 3W
	30.46	2.54	90.4	66.6	65.9	66.2	58.0	70.7	C, F, 4W

C = Ceiling.
F = Floor.
W = Wall.

Table 1*d*—Effect of Windows in the Test Room

Number of Sections in Radiator	Total E.D.R.	E.D.R. Per Section	Inside Surface Temperatures of Test Room, Deg F						Remarks
			North Wall	West Wall	South Wall	East Wall	Floor	Ceiling	
12	30.46	2.54	90.4	66.6	65.9	66.2	58.0	70.7	No windows
12	30.64	2.55	91.1	66.7	66.1	66.4	58.7	71.3	Two windows, one at each end of radiator
12	31.15	2.60	.....	64.8	63.7	64.1	56.5	68.9	Two windows, one back of radiator

Additional tests were made using a 12-section, 6-tube, 25-in. radiator with 1¾ in. spacing of sections. This radiator was tested under the following test room conditions: First, with no extra insulation; second, with the ceiling insulated; and third, with the ceiling, floor, and three walls insulated.

The effect of adding the ceiling insulation was to increase the output of the radiator 4.8 per cent. When the ceiling, floor, and the three walls were insulated, the output was increased 8.6 per cent over that which was shown when no insulation was used.

Effect of Windows

The tests thus far described were made in a test room which had no windows. The ASHVE radiator test code discourages the use of windows although it permits a window not larger than 16 sq ft. An investigation of several test rooms in use at the present time reveals that many of them have windows.

In order to find the effect of windows on radiator heat output as well as on temperature gradient within the test room, the following experiments were performed:

1. A test was made when the test room contained no windows.
2. A second test was made with two windows, each 32 in. by 60 in. The radiator was installed midway between the windows.
3. A third test was made with one of the windows placed directly back of the radiator.

The windows were set in the north wall of the test room, the sill being 20 in. above the floor level. All cracks around the window sash were carefully sealed with tape to

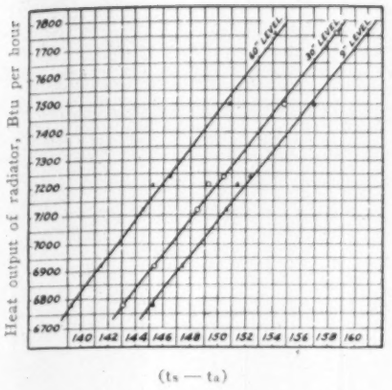


Fig. 10 — Relationship between heat output of radiator and temperature difference of steam and air at different levels

minimize leakage of air. The walls, floor, and ceiling of the test room were insulated with 3 in. of mineral wool and ¼ in. plywood board. The wall back of the radiator was insulated in such a manner that its overall heat transfer coefficient was 0.24.

The tests were conducted in the manner prescribed by the code except that the temperature at the center of the test room was kept constant at the 30-in. level instead of at the 60-in. level.

The results of these three tests are shown in Table 1*d* and in Fig. 9. It is evident that the effect of windows on radiator output and temperature gradient was negligible when the radiator was installed between the windows.

When one of the windows was placed directly back of the radiator, the difference in radiator output became more pronounced. For the radiator tested the output was increased 2.4 per cent above that which was shown when no windows were used. In this particular case the higher output was partly due to radiant heat loss to the cold window.

Determination of Exponent *n* for the Correction Factor

In general, when testing radiators, it is difficult to maintain standard temperature conditions of steam and of air at the center of the test room. There are, however, two methods by which the radiator output can be brought to the standard conditions. One method is to obtain data on radiator output both above and below standard temperature conditions and then plot the data, as in Fig. 10. From the curve thus obtained, the output at standard conditions may be found. The second method is by using a correction factor.

The first method requires a great deal of time and several test runs to obtain sufficient points for a plot. The second method requires but one run and is, therefore, preferable for ordinary testing. The correction is usually made as follows:

$$Q = Q_a \left(\frac{t_c - t}{t_s - t_a} \right)^n$$

in which

Q = heat given off by radiator at standard conditions, Btu per hour
Q_a = heat given off by radiator at the conditions of test, Btu per hour
t_c = temperature of the steam at standard conditions, degree Fahrenheit
t = temperature of the air at standard conditions, degree Fahrenheit
t_s = average temperature of the steam, degree Fahrenheit
t_a = average temperature of the air at center of test room at the required level, degree Fahrenheit
n = an exponent.

$$\left(\frac{t_c - t}{t_s - t_a} \right)^n = \text{correction factor.}$$

The ASHVE radiator test code specifies that the steam pressure shall be one pound, the air temperature 70 F at the center of the test room at a height of 5 ft from the floor, and n, the exponent for the correction factor, 1.3.

For these conditions, assuming that the barometric pressure is 29.92 in. Hg, which was no doubt intended, the correction factor becomes

$$\left(\frac{215 - 70}{t_s - t_a} \right)^{1.3} = \left(\frac{145}{t_s - t_a} \right)^{1.3}$$

From experience with tests made in the Mechanical Laboratories of the College of Engineering, Cornell University, in both commercial testing and research work it appears that the 30-in. elevation above the floor is preferable to the 60-in. for the control point of the test room temperature. This is clearly illustrated in Fig. 8 which shows only a small variation in radiator output when the 30-in. elevation was kept constant at 66 F, as compared with a larger variation in output when the 60-inch elevation was maintained at 70 F.

The 66 F temperature for the 30-in. elevation was selected because for room conditions showing the minimum temperature gradient a temperature of 66 F existed at the 30-in. level when the temperature at the 60-in. level was 70 F.

Tests were made to determine the correction factor which should be used when the temperature of the test room is maintained at the 30-in. elevation. In connection with these tests, information was obtained to verify the value of the exponent 1.3 for the 5-ft level. In the conduct of these tests the absolute pressure of the steam was maintained at 31.9 in. of mercury and data taken with the test room temperature constant at the desired elevation.

The results were plotted on both rectangular cross-section paper (shown in Fig. 10) and on log-log cross-section paper (shown in Figs. 11 and 12) with the radiator output in Btu per hour as ordinates and the coefficient C as abscissae.

Fig. 11 shows the results obtained by varying the room temperature between 61 F and 76 F at the 60-in. elevation. The slope of the line gives a value of $n = 1.33$. The graph in Fig. 12 shows the results of varying the room temperature between 56 F and 72 F at the 30-in. elevation. The slope of the line gives a value of $n = 1.31$. These results indicate that the value 1.3 is satisfactory for practical purposes within the limits given above.

A Comparative Method for Rating Radiators

Assuming that it is desirable to adhere to the condensation method, perhaps with some modifications, for rating radiators, it appears desirable

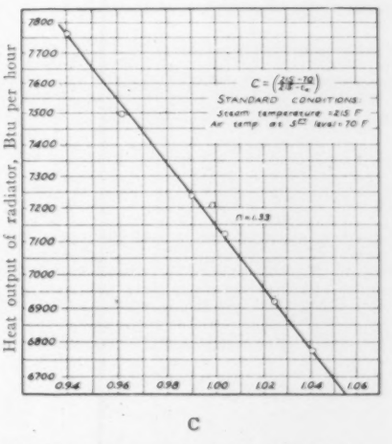


Fig. 11—Log plot of the relationship between heat output of radiator and coefficient *C* for the 5-ft level

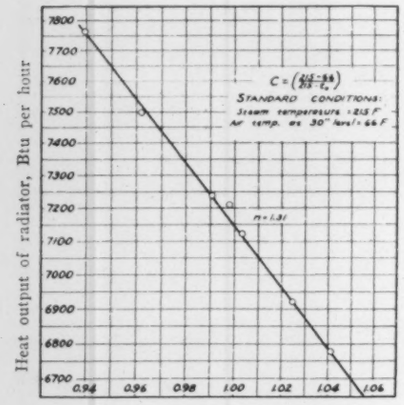


Fig. 12—Log plot of the relationship between heat output of radiator and coefficient *C* for the 30-in. level

to have an alternative method for the use of manufacturers or even consumers who do not wish to install and maintain the equipment necessary to make tests as prescribed by the ASHVE code, but who have access to various sizes of radiators, which have been rated in the standard way, to use for comparison. This method can be used in the following manner: A radiator whose output is known is connected to the same steam line as the radiator whose output is to be determined. The ratio of their condensates is taken, then, as the ratio of their ratings.

The pipe connections to the two radiators should be symmetrical with respect to the steam line. These radiators can be tested in a large room regardless of its exact air temperature. The only precautions to be taken are that the two radiators shall not be too greatly different in capacity nor in their general construction, that both radiators be similarly exposed to the cold surfaces within the room, and that the radiators be subjected only to natural convection of the air.

Tests made at Cornell with a parallel arrangement under three different conditions gave the following results: Under the first condition the radiators were placed in the center of a very large room and about 4 ft apart end to end. The ratio of radiator output of *A* to that of *B* was 1.011. The computed E.D.R. (equivalent direct radiation) for radiator *A* was 53.23 and for radiator *B*, 52.66.

These radiators were then set up in the same manner and tested in a completely enclosed 12 ft x 15 ft x 8 ft 6 in., galvanized iron room. The ratio of condensation of *A* to *B* was 0.985 while their respective E.D.R. were 70.29 and 71.41.

A third test was made using the galvanized iron room with the wall opposite the radiator removed. For this test the ratio of *A* to *B* was then 0.996 while their respective E.D.R. were 55.19 and 55.44.

The results show a maximum variation in the output of the two radiators of about 35 per cent, whereas the maximum variation in the ratio of the output of radiator *A* to that of radiator *B* was only 2.6 per cent.

Summary of Results and Conclusions

1. If two radiators of the same design are tested individually in the same test room, the one containing the larger number of sections will show the higher heat output per section. For tests made to demonstrate this difference the increase was 6 per cent.

2. Test room insulation affects the heat output of a given radiator. For the radiators tested, the largest increase in radiator output occurred when the entire room, except the wall immediately back of the radiator, was insulated. This increase was 6 per cent for the 12-section, 5-tube radiator and 8.6 per cent for the 12-section, 6-tube radiator.

Insulation of the ceiling accounts for the major portion of this increase. For the tests made under code specifications, ceiling insulation alone was responsible for 4.4 per cent of the total of 6 per cent increase which occurred when the floor, ceiling, and three walls were insulated.

3. The 30-in. level is a better height than the 60-in. level for the temperature control point of the test room. As shown in Fig. 8, with ceiling, floor, and three walls insulated the maximum increase in radiator output was 2.4 per cent when the temperature at the 30-in. level was kept constant as compared with a 6 per cent increase when the temperature at the 60-in. level was kept constant.

4. When infiltration of air was kept to a minimum, the installation of two windows in a standard test room had a negligible effect on radiator heat output.

The tests here reported show that there was practically no effect on radiator output when two windows were installed, with the radiator placed between them. However, when one of the windows was placed directly back of the radiator, the radiator heat output was increased 2.4 per cent.

5. The exponent, *n*, for the correction factor which is used to correct the results to standard conditions may be taken as 1.3 when the standard temperature is 66 F at the 30-in. level or 70 F at the 60-in. level.

6. A comparative method of test based on condensation can be used for the rating of radiators. This method is simple and with certain precautions should yield results well within 2.5 per cent accuracy.

Discussion

E. K. CAMPBELL, Kansas City, Mo.: There is one feature about this paper that interests me which pertains to the low temperature gradient within the room when the radiator is not operating at full capacity. I think it is true of any type heating equipment whether it be furnace or radiator, when it is operating at full capacity that it will heat the air that passes over it to a higher temperature, and thereby increases temperature gradient within the room.

The previous speaker questioned on the advisability of selecting and installing over sized radiators. Due to the fact that when a radiator frequently operates with a lower than design temperature, a reduction in room temperature gradient, in my opinion, should be taken into account when considering this question. In my judgment a larger radiator will function more economically if it has the proper controls installed to prevent over-heating.

PROF. W. M. SAWDON, Ithaca, N. Y.: It is true that the temperature gradient is one of the important factors. As was shown in this paper the greatest effect on temperature gradient was the insulation applied to the ceiling. It is impossible for me to state at this time how the effect of size of radiator might affect the temperature gradient of a room.

Corrosion Tests in a Water-Recirculating Air Conditioning System

By W. Z. Friend,* New York, N. Y.

This paper results from an investigation sponsored by the ASHVE Research Technical Advisory Committee on Corrosion†

SUMMARY—**Corrosion tests of eighteen ferrous and non-ferrous metals and alloys were made in a large air conditioning system. The tests were made in wash water in the bottom of the humidifier and in washed air stream beyond the eliminators. The corrosion rates of all metals and alloys tested in the dichromate-treated wash water were extremely low and confirm the effectiveness of this treatment. Localized attack in the form of pitting may occur on steel in crevices or under accumulations of solids. Corrosive conditions are particularly severe in the air stream just beyond the eliminators. Here the non-ferrous metals and alloys and stainless steels are most resistant. Alloy steels are superior to mild steel.**

IN water recirculating types of air conditioning systems, the problem of corrosion has been considerably moderated by the common use of chemical treatment of the wash water. So far as the dehumidifier or water spray chamber itself is concerned, corrosion can be virtually eliminated by the use of proper chemical treatment and this protection seems to extend to all parts of the chamber wetted with the water spray and to the prevention of serious galvanic action between non-ferrous valves or spray nozzles and adjoining steel or galvanized piping.[1] However, this chemical protection does not extend to the portions of the equipment directly beyond the eliminators. Consequently, in these parts—the fan and fan housing, ducts immediately adjacent to fan housing, duct between fan and eliminators, and parts of the eliminators themselves—corrosion may still be a serious problem.

Corrosion in the previously described parts of air conditioning systems is usually due to the presence of sulfur dioxide in the entering air, which when mixed with water forms dilute sulfurous acid. As would be expected, corrosion is usually most severe in industrial districts or in large cities where the sulfur dioxide content of the air is highest.

Treatment of the wash water with the proper combination of sodium dichromate and sodium hydroxide is usually effective in preventing appreciable corrosion in the dehumidifier itself by neutralization of part of the sulfurous acid and inhibiting attack by the remainder. However, the sulfur dioxide is usually not entirely removed from the air by this treatment[2] and, furthermore, the dichromate is not carried over into the air stream leaving the spray chamber.[3] Alternate changes in temperature of the air stream caused by the operation of automatic controls result in the condensation and evaporation on metal surfaces of aerated water. This water condensing from the vapor phase in the air stream contains no inhibitor and may contain traces of sulfur dioxide so that it is highly active as a corroding agent. Consequently, it is to be expected that corrosive conditions will be most severe in the parts of the system just beyond the eliminators.

The tests described in this paper were made to determine the resistance of a number of common ferrous and non-ferrous metals and alloys to corrosion under the conditions existing beyond the eliminators, and also in the wash water inside the dehumidifier in a system where proper chemical treatment was being given. The air conditioning system of the National Broadcasting Company at New York was selected as the location for the tests because it is representative of best modern practice, handles a large volume of large-city air, operates 20 to 21 hours per day during the entire year, and because of the excellent cooperation and supervision provided by the operating personnel. The operations so far as air washing is concerned follow the usual sequence. Air is drawn in from tenth-floor level through dry filters and baffles into the water spray chambers, then through the eliminators, the fan, and out into

*Development and Research Division, International Nickel Co., Inc.

†*Committee Personnel:* A. R. Mumford, *Chairman;* H. E. Adams, N. D. Adams, J. F. Barkley, L. F. Collins, W. H. Driscoll, T. J. Finnegan, W. Z. Friend, R. R. Seeber, E. T. Selig, Jr., F. N. Speller, C. M. Sterne and J. H. Walker.

[1]The Control of Corrosion in Air Conditioning Equipment by Chemical Methods, by C. M. Sterne. (*ASTM Proceedings,* Vol. 35, Part II, 1935, p. 261.)

Presented at the 48th Annual Meeting of the American Society of Heating and Ventilating Engineers, Philadelphia, Pa., January, 1942.

[2]A Study of the Removal of Sulfur Dioxide from Library Air. (*National Bureau of Standards,* Miscellaneous Publication No. 142.)

[3]Loc. Cit. Note 1.

Table 1—Analyses of Wash Water—Parts Per Million
(Water filtered before analysis)

Analysis No.	1	2	3	4
Date	1-2-39	1-3-39	5-24-39	5-24-39
Location	North Dehumidifier	South Dehumidifier	North Dehumidifier	South Dehumidifier
Mineral Substances				
Silica	12	10	4	5
Iron and Alumina	13	13	2	2
Calcium Oxide	55	55	2	8
Magnesium Oxide	3	3	—	—
Bicarbonates as Calcium Carbonate	175	180	160	190
Chlorides	28	28	18	18
Sulfates	406	449	102	92
Chromates as Sodium Bichromate	452	365	313	313
Suspended Matter	Present	Present	Present	Present
Total Solids (Gr.–Gal.)	83.5	83.1	40	40.4
Hardness as $CaCO_3$ (Gr.–Gal.)	5.9	5.9	0.2	0.8
Total Incrusting Solids (Gr.–Gal.)	11.3	11.3	0.7	1.8
Total Non-Incrusting Solids (Gr.–Gal.)	72.2	71.8	39.3	38.6
Organic Matter	Present	Present	Present	Present
pH	7.9	7.9	7.9	7.9

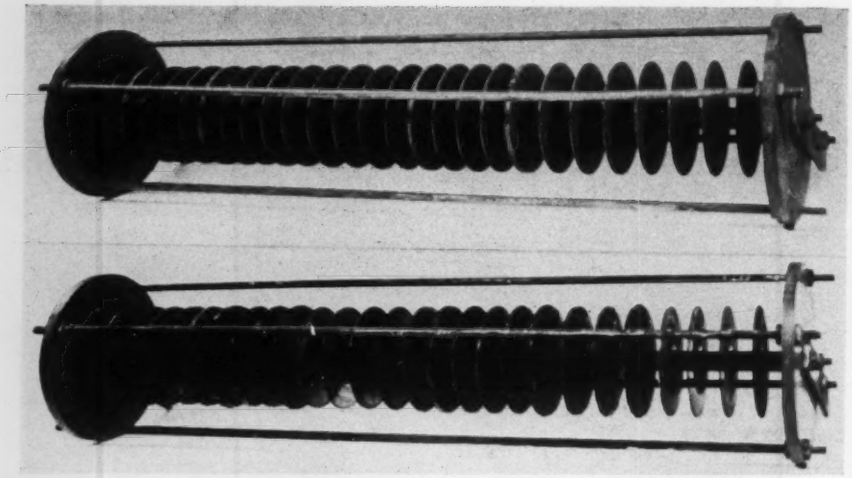


Fig. 1—Corrosion test spools after removal from test and before cleaning
Top: Spool from sodium dichromate—sodium hydroxide treated water in dehumidifier
Bottom: Spool from washed air stream between eliminators and fan

the duct system. The wash water is recirculated and in summer is cooled by refrigeration. Typical analyses of the circulating wash water taken from both the north and south dehumidifiers are given in Table 1. These show the difference in the water when the equipment is running during the refrigeration season (dehumidifying) and during the winter season (humidifying). All four analyses were made during the corrosion test period.

During the refrigeration season, water is being removed from the air and there is a certain amount of water running to waste through the overflow line at all times. Consequently, the water is being diluted with what is in effect distilled water. This condition is shown by analyses 3 and 4. During the winter season, water is being added to the air at all times. There is no loss of water by means of overflow, but there is a constant inflow of water to make up for that evaporated into the air stream. Hence, there is a concentrating effect in the wash water as shown by analyses 1 and 2.

All of the recirculated wash water is treated with both sodium dichromate and sodium hydroxide. The dichromate concentration is maintained at 300 to 350 ppm and the *pH* value at 7.8 to 8.2. Determinations of *pH* are recorded continuously in a glass electrode recording potentiometer. Sodium dichromate determinations in each recirculating water circuit are made daily by the potassium iodide-sodium thiosulfate titration method.

The corrosion test specimens were assembled on test spools[4] as shown in Fig. 1. The method of testing was in accord with the *ASTM* Tentative Recommended Practice for Conducting Corrosion Tests.[5] Briefly, the method consists in assembling uniform, weighed specimens of the various materials on a spool so that they are completely insulated from each other and from the metallic parts of the spool. A plastic tube covers the center structural rod of the spool and the specimens (each having a hole in the center) are strung on this tube with pieces of larger plastic tube $\frac{5}{8}$ in. long between each specimen. On each end of the spool is a 4 in. diameter plastic disc which serves to keep the specimens away from the sides of the operating equipment and to act as support for other structural rods.

Typical analyses of metals and alloys included in these tests are given in Table 2. The test specimens of wrought materials are made from $\frac{1}{32}$ in. sheet or strip of the commercial materials. They are machined to exactly 2.233 in. outside diameter with a $\frac{21}{64}$ in. diameter hole in the center. These dimensions are chosen so that when assembled on the spool the exposed area of each specimen is 0.5 square decimeter. Specimens of cast materials were machined to $\frac{3}{16}$ in. thickness with the diameter correspondingly smaller so that exposed area was the same as for wrought materials. Before assembly, the specimens were prepared by scrubbing with powdered pumice and a bristle brush to remove dirt or rust completely, rinsing in water followed by alcohol-ether, drying, and weighing on an analytical balance to the nearest 0.0001 gram. Four spools were prepared—two for each test location. Each spool contained one specimen of each material being tested. This gave duplicate specimens in each location.

The spools were placed in test in the north unit on February 22nd, 1938, while the equipment was shut down for a short period at night. Two of the spools were suspended in the wash water in the bottom of the spray chamber not far from the water overflow. They were suspended horizontally so that the specimens were always immersed in water but above any layer of solids

[4]Corrosion Testing Methods, by H. E. Searle and F. L. LaQue. (*ASTM Proceedings*, Vol. 35, Part II, 1935, p. 249.)
[5]Tentative Recommended Practice for Conducting Plant Corrosion Tests (*ASTM* Designation: A224-39T, 1939).

Table 2—Approximate Chemical Compositions of Materials Included in Corrosion Tests

Material	Approximate Chemical Composition—Per Cent by Weight								
	Ni	Cr	Cu	Fe	C	Mn	Si	Zn	Other
Monel	67.	—	30.	1.4	0.15	1.	0.1	—	—
Nickel	99.4[a]	—	0.1	0.15	0.1	0.2	0.05	—	—
Inconel	79.5	13.	0.2	6.5	0.08	0.25	0.25	—	—
18-8 Stainless Steel (Type 304)	8.	18.	—	Bal.*	0.08[b]	—	—	—	—
70-30 Copper-Nickel Alloy	30.	—	70.	—	—	—	—	—	—
Copper	—	—	99.9+	—	—	—	—	—	—
Silicon Copper	—	—	94.5	—	—	1.	4.5	—	—
Admiralty	—	—	70.	—	—	—	—	29.	Sn—1
Zinc	—	—	—	0.05	—	—	—	98.65	(Pb—0.8 (Cd—0.5
5% Nickel Steel (SAE 2512)	5.	—	—	Bal.	0.20[b]	0.60[b]	—	—	—
3½% Nickel Steel (SAE 2315)	3.5	—	—	Bal.	0.20[b]	0.60[b]	—	—	—
Nickel-Copper Alloy Steel	2.	—	1.	Bal.	0.08	0.44	—	—	—
Copper-Bearing Steel	—	—	0.20[c]	Bal.	0.07	0.35	—	—	—
Mild Steel	—	—	—	Bal.	0.25[b]	0.60[b]	—	—	—
Wrought-Iron	—	—	—	Bal.	0.05[b]	0.05[b]	0.15[b]	—	—
Ni-Resist	14.	2.	6.	Bal.	3.	1.25	1.5	—	—
3% Nickel Cast-Iron	3.	—	—	Bal.	3.2	0.5	1.	—	—
Plain Cast-Iron	—	—	—	Bal.	3.2	0.5	1.5	—	—

[a]Including cobalt.
[b]Maximum.
[c]Minimum.
Balance in every case includes impurities not otherwise listed.

which might collect on the bottom of the chamber. The other two spools were suspended horizontally by wires in the washed air stream between the eliminators and the fan. They were located about 24 in. from the eliminators and about centrally from side to side and top to bottom.

The tests were discontinued on October 5, 1939, giving a test period of 590 days. The spools were taken directly from the equipment, allowed to dry and photographed. One spool from each location is shown in Fig. 1. The specimens were removed and cleaned by electrolytic treatment in an inhibited acid bath,[6] followed by brushing, washing in water and in alcohol-ether, drying and weighing. Corrosion rates were calculated in milligrams loss per square decimeter per day (Mdd) and inch penetration per year (Ipy) as shown in Tables 3 and 4. The rates shown are the average of two specimens of each material. In converting from milligrams per square decimeter per day to inch per year, the following equation was used:

$$Ipy = Mdd \times \frac{0.001437}{d}$$

where

d = density of metal or alloy in grams per cubic centimeter.

Depth of pitting or localized corrosion was measured microscopically with an accuracy of 0.001 in. Column 4 of Tables 3 and 4 shows the maximum depth of pitting, if any, which occurred at and in the crevice between the specimen and the adjoining Bakelite spacer. Column 3 shows the maximum depth of pitting, if any, which occurred on the exposed surface of the specimen.

[6]Loc. Cit. Note 5.

Results in Wash Water

The weight losses of all the materials tested in the dichromate treated wash water were extremely low and confirm the effectiveness of this treatment in inhibiting corrosion. The general performance of mild steel and plain cast-iron is so good that there would ordinarily be no point in using more expensive materials for the fabrication of the spray chamber itself where this treatment is given. However, particular attention should be given to the pitting which occurred underneath and adjacent to the spacers with all of the steels and cast irons tested. Practically all of the *surface* pitting shown in Column 3 of Table 3 actually occurred in areas adjacent to the spacers where solid deposits from the water might get a foothold in the crevice between specimen and spacer and tend to accumulate. This pitting is similar to that which may occur with some metals and alloys due to the presence of oxygen concentration cells.[7] In that case the surface of metal freely exposed to an aerated solution is passivated by the oxygen present. However, in crevices or underneath surface deposits not receiving free circulation and aeration, the oxygen may become used up and the metal lose its passivity and assume an *active* state. Under these conditions a small electrolytic cell may be set up between the passive and active surfaces causing accelerated corrosion of the latter. Under favorable conditions, cells of this type may develop potentials as high as 500 millivolts or more.

In the present case, potassium dichromate is a *passivator* of steel and its corrosion inhibiting properties are due to this fact. It is probable that in this test the accumulation of some solid deposit from the water at the spacers prevented the free access of dichromate to the surface in and near the crevices with the result that these surfaces were in a more *active* condition than the adjoining surfaces and thereby suffered accelerated corrosion of the concentration cell type. In the case of mild steel, the maximum depth of this pitting was 0.007 in. in 590 days. Where the metal used is fairly heavy, such a rate may not be particularly serious. Also, the pitting may tend to be more prevalent in the wash water in the bottom of the spray chamber where solids tend to accumulate than it would be on the sides of the chamber which are continuously washed down. However, it is apparent that cracks and crevices should be avoided as much as possible in fabrication. The pitting which occurred in the zinc specimens is of particular significance since zinc is generally applied as a galvanized coating which would soon be penetrated by this rate of localized attack.

[7]Corrosion Resistance of Metals and Alloys, by R. J. McKay and R. Worthington. (*American Chemical Society*, Monograph No. 71, Reinhold Publishing Corp., 1936, p. 41.)

Results in Washed Air Stream

The results of the tests in the washed air stream are given in Table 4. A further idea of the severity of corrosion may be obtained from Fig. 2 showing one cleaned specimen of mild steel from each test location. In the air stream

Table 3—Corrosion Tests in Recirculated Wash Water in Dehumidifier

Material	Avg. Corrosion Rate		Max. Depth Pitting—Inch	
	Mdd	Ipy	Surface	Under Spacer
Monel	0.005	<0.00001	None	None
Nickel	0.013	<0.00001	None	None
Inconel	0.006	<0.00001	None	0.002
18-8 Stainless Steel (Type 304)	0.001	<0.00001	None	0.001
70-30 Copper-Nickel Alloy	0.007	<0.00001	None	None
Copper	0.011	<0.00001	None	None
Silicon Copper	0.024	<0.00001	None	None
Admiralty	0.024	<0.00001	None	None
Zinc	0.27	0.00006	0.012	0.009
5% Nickel Steel (SAE 2512)	0.21	0.00004	None	0.007
3% Nickel Steel (SAE 2315)	0.28	0.00005	0.006	0.010
Nickel-Copper Alloy Steel	0.93	0.00017	0.006	0.010
Copper-Bearing Steel	0.22	0.00004	0.004	0.007
Mild Steel	0.25	0.00005	0.005	0.007
Wrought-Iron	0.21	0.00004	0.003	0.012
Ni-Resist	0.20	0.00004	0.003	0.011
3% Nickel Cast-Iron	0.56	0.00011	0.005	0.009
Plain Cast-Iron	0.54	0.00011	0.004	0.017

< = less than.

Table 4—Corrosion Tests in Washed Air Stream Between Eliminators and Fan

Material	Avg. Corrosion Rate		Max. Depth Pitting Inch	
	Mdd	Ipy	Surface	Under Spacer
Monel	0.19	0.00003	0.001	0.001
Nickel	0.09	0.00001	0.002	0.003
Inconel	0.015	<0.00001	0.004	0.003
18-8 Stainless Steel (Type 304)	0.015	<0.00001	0.001	0.003
70-30 Copper-Nickel Alloy	0.42	0.00007	None	None
Copper	0.49	0.00008	None	None
Silicon Copper	0.42	0.00007	None	None
Admiralty	0.59	0.00010	None	None
Zinc	0.23	0.00005	Incipient	None
5% Nickel Steel (SAE 2512)	24.1	0.0044	*	*
3% Nickel Steel (SAE 2315)	35.7	0.0065	*	*
Nickel-Copper Alloy Steel	28.2	0.0052	*	0.006
Copper-Bearing Steel	36.9	0.0068	*	0.006
Mild Steel	54.2	0.010	Perforated	*
Wrought-Iron	37.4	0.0069	Perforated	0.004
Ni-Resist	6.4	0.0012	*	0.006
3% Nickel Cast-Iron	46.3	0.0091	*	0.005
Plain Cast-Iron	62.1	0.0124	*	*

< = less than.
*Roughened surface due to general corrosion.

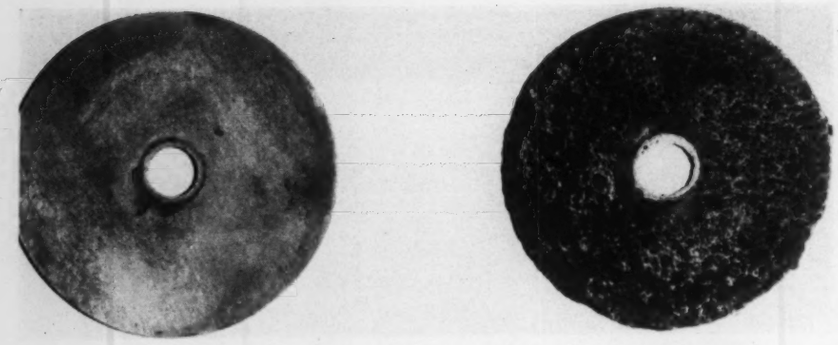


Fig. 2—Mild steel specimens after removal from test and cleaning
Left: Specimen from sodium dichromate—sodium hydroxide treated water in dehumidifier. Note the local attack adjacent to spacer
Right: Specimen from washed air stream between eliminators and fan

tests, as in many atmospheric exposures, the alloy steels show definite advantages over mild steel, 5 per cent nickel steel and nickel-copper alloy steel, having twice the resistance of mild carbon steel. Corrosion of all the steels is sufficiently great, however, that where an unprotected metal surface is to be used, the selection would probably be made among the high nickel or copper alloys, stainless steels, or possibly galvanized steel. The zinc specimens showed evidence of some incipient pitting (numerous very fine pits less than 0.001 in. deep) and, hence, would be questionable for this location between eliminators and fan where condensation may occur. In the dryer portion of the duct system beyond the fan, galvanized steel is widely used and is apparently giving good performance.

Summary

In actual practice the use of mild steel and plain cast-iron covered with a suitably resistant asphalt-base paint is giving good performance in the spray chambers and eliminators of dichromate-treated systems which are readily accessible for frequent inspection and repair. The coating tends to fill in any cracks or crevices of the equipment and round out sharp corners where solids might otherwise collect. It also provides protection against corrosion in case the chemical treatment is discontinued for short periods due to neglect or breakdown. In a system where frequent inspection and repair cannot be made it is conceivable that the coating might, under certain conditions, do more harm than good. Cracks or holes in the coating which persisted for a considerable time might provide the starting points for accelerated localized corrosion. In any event, it is advisable to avoid cracks and crevices as much as possible. In the spray chamber in which these tests were made, unpainted nickel-copper alloy spray nozzles are being used with painted steel nipples without appreciable galvanic corrosion of the latter.

The most severe corrosive condition exists in the washed air stream from the eliminators to the fan. In some systems the use of acid-resisting synthetic resin-base paints is apparently giving satisfactory protection in this area. Nickel or nickel-copper alloy steels have sufficiently better resistance than mild steel to warrant their use under these paints for protection in case the coating becomes broken or worn off for considerable periods without repair. For parts not available for frequent inspection and repair the use of the highly resistant metals or alloys, such as the high nickel or copper alloys or stainless steels, is indicated. This applies particularly to the fan and fan housing which may be subject to considerable erosion as well as to corrosive attack.

Acknowledgments

The author wishes to express appreciation to Robert Close, Chief Air Conditioning Engineer, National Broadcasting Co., Inc., and his associates for permission to conduct and for their assistance in conducting the foregoing tests; also, to C. M. Sterne, Chief Engineer, Metropolitan Refining Co., Inc., for water analyses and for details of water treatment.

Discussion

C. M. Sterne, Long Island City, N. Y. (Written): This paper shows the results of the first quantitative tests run to determine the actual corrosion resistance of various ferrous and non-ferrous metals and alloys in those parts of air conditioning systems that cannot receive chemical water treatment.

It is a well known fact that proper water treatment does control corrosion of the common metals used in the construction of commercial air conditioning systems.

It was unfortunate that no aluminum alloys were included in the tests, as varying degrees of resistance to corrosion of these metals have been found under the test conditions outlined. Tests of various protective coatings should be made in this equipment, as the same conditions still prevail.

Fig. 2 is of very great interest, as the contact corrosion which appears adjacent to the spacer on the mild steel specimen from the treated water is now no longer a problem. By means of proper non-corrosive, neutral fungicides it has been found possible to completely inhibit all organic growth in the recirculated water. Formerly contact corrosion was a serious problem and some work was done by Mears and Evans in England in 1934, but little explanation was given.

It is the writer's opinion that contact corrosion is due to the formation of differential oxygen concentration cells in the crevice spaces at the point of contact due to the fact that organic matter can collect there and keep the treated water from contact at these points. We have found, however, that by using pentachlorophenols or pentachlorophenates that we no longer have organic growths in crevices, and therefore there is no formation of differential oxygen concentration cells.

This paper clearly proves the corrosion problems that are found beyond the eliminators. This type of attack is especially severe in evaporative condensers and induced draft cooling towers. The writer has found in many cases heavy scaled formation on evaporative condenser tubes and equally heavy corrosion of the fans and fan housings 2 ft away from the scaled portions of the equipment.

F. N. Speller, Pittsburgh, Pa.: The remarks of Mr. Sterne about fungus growth around the contact of the specimens should not be confused with what was previously mentioned about the general presence of organic matter in water. It is well known how algae and fungii can be stopped, but organic matter such as humus will reduce the chromates to a chromous salt, which has no productive value. This problem is not serious for city water, unless it has become contaminated, such as by drainage over roofing material or some other surface of this nature.

Proceedings of Annual Meeting 1942

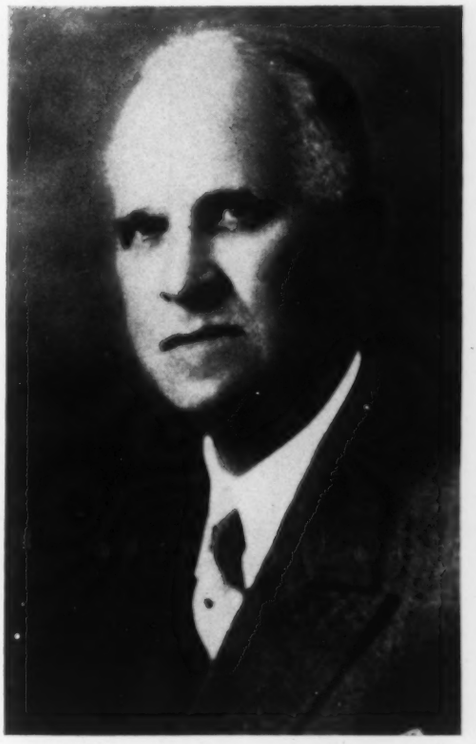
AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

W. L. Fleisher, New York, N. Y.
President—1941

Bellevue-Stratford Hotel

January 26-28, 1942

Philadelphia, Pa.



E. O. Eastwood, Seattle, Wash.
President—1942

FIRST SESSION—Monday, January 26, 9:30 A.M.

The 48th Annual Meeting of the Society opened at the Bellevue-Stratford Hotel, Philadelphia, January 26 with a business session for members and Pres. W. L. Fleisher called the meeting to order at 10:00 a. m. He introduced M. F. Blankin, General Chairman of the Committee on Arrangements, for the Philadelphia Chapter who presented the Hon. Charles H. Grakelow, Director of Purchases and Supplies of the City of Philadelphia, who on behalf of Mayor Bernard Samuel, presented greetings and a warm welcome to the city. He stressed the importance of the city's contribution to the National Defense Program and its wealth of valued historical inheritances from the early days of the founding of the country. He expressed the hope that members would take advantage of the opportunity, "to visit the Cradle of Liberty and stand by that hallowed Bell whose metal tongue has long since been silent and yet which wields an influence the like of which I cannot describe, as evidenced by the men and women who come from all sections of America to kneel in adoration and homage and gratitude for all it has meant to us in these years."

President Fleisher responded briefly on behalf of the Society Members.

The personnel of the Resolutions Committee was announced by President Fleisher as follows: Lester T. Avery, Cleveland, *Chairman;* C. E. Bentley, San Francisco, and Brig.-Gen. W. A. Danielson, Memphis.

President Fleisher introduced Arthur W. Nass, President of the *Heating, Piping and Air Conditioning Contractors National Association* who brought greetings from his members and presented an interesting discussion about the relationship between the engineer and the contractor. He briefly outlined some of the problems involved and expressed the thought that a frank discussion of these matters was desirable. President Fleisher expressed appreciation for the thoughts expressed and said that he believed the recommendations offered should be studied by a Committee.

President Fleisher then read his prepared address:

President's Address

It is customary, when a President has completed his term in office, to review the important things that have transpired during his encumbency, to record what was accomplished and what can be done for the future development of the Society.

There is no need to tell you that 1941 was a trying year. The actual entry of the United States into the war, in December, had been so long anticipated, that only the tragedy of Pearl Harbor made it anything but an anti-climax. As a result of my visits to Europe in 1938 and 1939, it was my conviction that it would be impossible for the United States to stay out of a world war. Consequently, on my frequent appearances before the chapters throughout the country and before various other organizations and agencies, I stressed the necessity for adequate defense preparations and particularly civilian air raid protection, predicated primarily on ventilation of shelters.

While formerly the President of the Society made visits to the chapters in a continuous tour, during his term, lasting for about three weeks, the increase in the number of our chapters and the other arduous responsibilities of the President made it essential to spread these visits over a longer period of time, so in 1939 the First and Second Vice Presidents were assigned certain of these duties, in order to relieve the President. This plan has proved a very satisfactory method of distributing the duties of the executive officers of the Society and, I believe, should be continued. My own tours started some three years ago, and, according to my diary, ever since then I have been traveling extensively in the interests of the Society.

It has been my endeavor to focus attention upon the value of research and the educational importance of the Society, not only throughout the United States and Canada, but also in England, France, Belgium and Holland.

Upon entering the Presidency of the Society, I made a detailed study of the Society's fundamental policies and how its influence could be furthered and its technical investigations and research developed for the education of the public and the enhancement of its position in national affairs. This is something that must be very carefully considered, because particularly during the past year, when the government has been drawing from the various technical societies for advisory boards, the Society, in my opinion, has been overlooked and neglected, because it has not been considered one of the founder societies. The actual importance of the Society is so great, that it is only a lack of the understanding of its accomplishments that has put it in this position.

In order to carry through those things which might be considered essential for the advancement of the Society, I prepared and presented to the Council in April a statement of policy, which, unfortunately, (Russia not having come into the war as an ally) I called a five-year plan. A better name might have been chosen, but this plan which is on record in the Minutes of the Council, divided the work of the Society into those branches which I considered most important for its development and life:

1st—Research

2nd—Publications (I refer to the monthly publications), our GUIDE and something to take the place of the TRANSACTIONS

3rd—Education—that is, education of the members, education of the professions and education of the layman

4th—Codes and Standards to set the rules and guide the courts and municipalities

5th—Publicity to advertise the work of the Society in research, education and standards.

In this report research was emphasized—research as developed by the Society over its 20 odd years of investigation and the development of new research projects, which, to some members might seem inappropriate and out of place in the heating, ventilating and air conditioning field. The three matters that I stressed most particularly in this report were:

1st—the spread of our activities to include those things that actually are in line with our basic knowledge, such as those parts of aeronautics that might be considered air movement or air control, having to do primarily with the testing and not the design of planes.

2nd—continued stress on the physiological and medical aspects of air or air conditioning.

3rd—the matter of the method of publication of our research and educational work.

Another important part of the plan for the future welfare of the Society was the very thing which at this particular moment is threatening to jeopardize the research of the Society, namely, *money*, for carrying on research. This should be taken out of the realm of instability and I suggest that every means be adopted to create an endowment which will carry our research forward over trying periods. If necessary, I advocate that money be taken from the surplus of the Society to continue our research on an adequate scale during the war period and the depression which is sure to follow the war.

I wish to take this opportunity of expressing my appreciation of the tremendous assistance that your Secretary, Mr. A. V. Hutchinson, has contributed in carrying on the affairs of the Society. But I want to disabuse the minds of the members—and this I know I do with the full concurrence of Mr. Hutchinson—of the idea that the Secretary can run the Society. The tremendous duties that are imposed upon him by the publication of THE GUIDE, the general business of the Society and the innumerable calls on his time and energy leave him no time to develop or establish policies, nor to decide or pass upon the scientific activities with which the Society is most nearly concerned. The commendable work of the Technical Secretary, Mr. John James, and Director F. C. Houghten of the Laboratory should also be appreciated by the members.

In a society such as this, the executive officers should be scientifically minded and interested in research, and education, and the head of the Society not only must be familiar with all of these activities, but must be competent to pass upon any critical points that may arise in connection with them. Moreover, he is expected to understand showmanship almost as well as Barnum and to assist in the success of the expositions which may be held while he is in office. This year I had the unique experience of participating in the preparations for two expositions, one in San Francisco in June and the currently postponed exposition in Philadelphia at this time. Both of these took considerable time, which ordinarily the President of the Society is not called upon to give. It is also the duty of the President, if he is interested in research, to see how money can be obtained to support this work, and the contacts that he can make are very important. While a fine record has been made in this work by Mr. E. P. Heckel of the Finance Committee of Research, it has been necessary for me to devote considerable time in the last few months in an attempt to create interest in new research and also secure the necessary funds to conduct the work.

The past year has been a difficult one for your President for many reasons, as both the last Annual Meeting in Kansas City, and the Summer Meeting in San Francisco required unusually long absences from home and office. Also the necessity of conserving the funds of the Society made it essential for the President to avail himself of his locality to bring news of the Society to adjacent chapters.

These items are cited so that you may realize that although a man is greatly honored in being elected to this high office, his time and his duties sometimes impose burdens that the executive officers of the Society must be willing to contribute and be able to afford. One who serves as President will find that there is no week and practically no day in the entire year when some time must not be devoted to the work of the Society. This was my experience during the past year.

As one of my foremost interests has been in Society research for the last ten years, it was my good fortune to have Commander A. E. Stacey, Jr. accept reappointment as Chairman of the Committee on Research, and he devoted a large share of his time to this important work until he was called on by his government to enter active service in the U. S. Navy, during the latter part of 1941. Dr. Winslow, Vice-Chairman, was called to the west coast for a six month assignment, so he was handicapped somewhat in assisting the chairman. J. H. Walker, the Committee's Technical Adviser, had been on the sick list for many months but, fortunately, he could be active in the last few months and he has done an excellent job.

Consequently, your President has felt it his duty to keep in closer touch with research affairs than is usually customary for the President.

None of the problems of the Presidency have been mentioned with the idea of arousing your sympathy or soliciting your commendation. If I had not loved everything pertaining to the Society, if I were not devoted to research, if I did not feel that we had an opportunity to advance the comfort and health of humanity as no other organization has ever done, I undoubtedly would have found a way out of many of the arduous duties which the office imposes necessarily. But when one realizes the part that we as a Society and as individual members of this Society have been able to accomplish for the good of the country in the national emergency with which we are now entangled, one appreciates the joy with which one looks back on his association with this group.

During the October Council meeting in Washington, I tried to summarize the contribution of the Society to national defense, and it was a revelation to find how in practically everything entering into the conduct of the war the research of the Society has contributed considerably to the development of the implements of war and the projection of the people.

Our work over the past 20 years is crystallizing now in indicating what conditions of temperature and humidity are required for the maximum output of office workers, engineers and draftsmen, and the proper manufacture of war material. Blackout buildings have made the requirements for ventilation so important, that the work we have done on air conditioning requirements in industry is the basis of all ventilation design.

Our work in fever therapy is having its effect on the medical treatment of social diseases. Our work in operating rooms and convalescent wards is the basis of the proper design for carrying on the emergency work in hospitals, unfortunately so essential in the coming months.

Our research in spot cooling and proper clothing and the design of ventilation for hot spaces in ships and cold surroundings in stratosphere flying is being utilized by the Army and Navy.

Airplane plants, airplane body plants and an infinite number of other industrial institutions are profiting from our research work.

Our new cantonments are utilizing our research in heating, ventilating and air filtering.

There is practically not a single phase of production for defense in which the work of the Society is not playing a prominent part.

I am more than happy to have had the opportunity, at the conclusion of my long period of close association with the work of the Society, to have served as your President and executive head during this time of national emergency.

Respectfully submitted,

W. L. Fleisher,
President

The Secretary was requested to present a report of the Council which he read as follows:

Council Report

The Council held five meetings during the past year and carried out its duties under the Constitution and By-Laws and acted on all special matters which required its attention.

The Council held its organization meeting January 29, 1941 in Kansas City, Mo., with Pres. W. L. Fleisher presiding and there were 16 of the 18 members present. Announcement of Committee appointments was made and the Society's Budget for 1941, providing for $85,600 expense exclusive of Research was adopted. A Certified Public Accountant was appointed and depositories for Society funds were selected. The Secretary and Technical Secretary were reappointed.

The April Council Meeting was held in Toronto and a grant of $5000 from Society funds was made to the Committee on Research. The reports of Special Committees were received and the Program for the Summer Meeting in San Francisco was approved. President Fleisher submitted a program for the Promotion and Development of the Society which was discussed in great detail and these sections relating to publications were referred to a Special Committee; the topics covering educational work were referred to the Local Chapters Committee and the material bearing on Research was sent to the Committee on Research for study.

In June, the Council met in San Francisco and authorized the appointment of a Committee to cooperate with the *ASRE* and a Special Committee to study the proposal for publication of weather data. President Fleisher announced the appointment of a Special Committee on Medical and Engineering Research; an appropriation was made for the employment of special personnel for drafting code revisions and nomination of five members was made for a three-year term on the Committee on Research commencing in 1942. St. Paul was selected as the meeting place in June 1942.

Reports from Council Committees and Special Committees were received showing the current status of various activities.

In October the Council met at Washington, D. C. and established dues rates for 1942, heard a report on the progress of the 7th International Heating and Ventilating Exposition and voted on candidates for the F. Paul Anderson Award at the 48th Annual Meeting.

During the course of the year Life Memberships were granted to 12. Resignations of sixty members were accepted and cancellations of membership totaled 39. Death claimed 18 among which were Life Members: Alfred Kellogg, J. J. Blackmore, charter member, W. A. Shorb, J. J. Nesbitt, E. B. Gordon, Jr. and H. B. Gombers.

Respectfully submitted,

The Council.

The report of the Treasurer was presented by Mr. Blankin and emphasized the significant points in the Balance Sheet and the Budget Comparison prepared by the Society's Certified Public Accountant.

Tusa & LaBella
Certified Public Accountants
52 William St., New York

January 16, 1942.

American Society of Heating and
Ventilating Engineers,
51 Madison Avenue,
New York, N. Y.

Gentlemen:

Pursuant to your request, we examined the books of account and records of the American Society of Heating and Ventilating Engineers—New York, N. Y. and the related Funds for the year ended December 31, 1941 and submit herewith our report.

The audit covered a verification of the assets and liabilities as of the close of business December 31, 1941 and a review of the operating accounts for the year then ended. For the period audited the recorded cash receipts were traced into the depositories; the cancelled bank checks were inspected, compared with the cash records and supported by payment vouchers; also the dues income and interest income from savings accounts and securities was accounted for.

A Balance Sheet reflecting the financial condition of the Society as of the close of business December 31, 1941 is submitted herewith and your attention is directed to the following comments thereon:

CASH

Cash on Deposit and out for collection was verified by direct communication with the banks listed in the attached cash schedule and reconcilement of the balances reported to us with the amounts shown by the books of the Society.

The Cash on hand for Deposit and the Petty Cash was verified by count.

MARKETABLE SECURITIES

The securities, per the annexed schedule, were verified by direct communication with the Bankers Trust Company where same are deposited for safe-keeping. This asset has been included in The Balance Sheet at the cost of acquisition plus the accumulated and accrued interest earned thereon.

CERTIFICATE OF INDEBTEDNESS

During the current year the Society received a certificate of indebtedness No. 6 for the principal sum of $161.00 plus accumulated interest at 3%, for the period from March 1, 1933 to December 31, 1940, amounting to $37.84 in settlement of their open account. In the future the 3% interest is payable only on the unpaid balance of the principal.

ACCOUNTS RECEIVABLE

A list of the membership dues receivable as of December 31, 1941 furnished to us by the management was checked to the individual ledger cards and found in agreement with the General Ledger Control. These unpaid dues were aged and may be summarized as follows:

Dues Invoiced during 1941	$ 6,944.00
Dues Invoiced during 1940	3,044.12
Dues Invoiced during Prior Years	3,583.59
TOTAL	$13,571.71

Amounts due from Guide Advertisers and other debtors were verified by trial balance of the individual ledger accounts and found in agreement with the General Ledger Control.

The books of the Society reflect the following Reserves for Doubtful Accounts Receivable which we consider ample:

Reserve for unpaid dues	$7,501.54
Reserve for unpaid Advertisements and sundry receivables	1,291.37
TOTAL	$8,792.91

INVENTORIES

Items appearing under this caption are based upon quantities submitted by the management and computations made by us. The Transactions inventory priced at cost is scheduled below:

Volume	Year	Quantity	Price	Amount
-0-	Prior years	1750	$1.00	$1,750.00
41	1935	12	1.65	19.80
42	1936	24	1.65	39.60
43	1937	133	1.58	210.14
44	1938	146	1.58	230.68
45	1939	163	1.65	270.58
			TOTAL	$2,520.80

PREPAID TRAVELING

As of December 31, 1941 the Society possessed Railroad Scrip Books which were acquired at a cost of $3,212.05. This asset was verified by actual count of the scrip books on deposit with the Executive Secretary which we found to aggregate the above sum.

PERMANENT ASSETS

Furniture, Fixtures and Library are shown herein at the book values without appraisal by us. We did, however, provide for depreciation of furniture and fixtures at the rate of ten (10%) per cent per annum.

ACCOUNTS PAYABLE

Amounts due creditors were determined by inspection of the unpaid bills found on file and examination of the record of cash disbursements made subsequently to December 31, 1941.

DEFERRED INCOME

Trial balances taken of the dues and miscellaneous accounts receivable disclosed prepayments of 1942 dues and Guide advertisements which we have shown in the subjoined balance sheet under deferred income.

RESERVE FOR TRANSACTIONS

There remain to be published Transactions for 1940—Volume 46 and 1941 Volume 47. In providing reserves for these commitments we have retained the sum of $3,900.00 for Volume 46 and estimated the cost for Volume 47 at $3,700.00.

GENERAL FUND

An analysis of the General Fund showing the changes that occurred in this account during the calendar year 1941 follows:

BALANCE—JANUARY 1, 1941—PER FORMER REPORT		$84,892.16
Additions		
Excess of Income over expenses on Guide Operations for the Year ended December 31, 1941 from Guide Statement of Income and Expenses	$3,262.96	
Excess of Income over Expenses on Society activities for the year ended December 31, 1941 from Society Statement of Income and Expenses	1,823.49	
Exchange service plan accommodation Account closed out	106.76	
Accumulated Interest credited for the period from March 1, 1933 to December 31, 1940 in settlement of account Payable to the Society	37.84	5,231.05
BALANCE—December 31, 1941—Per BALANCE SHEET		$90,123.21

SPECIFIC FUNDS

The cash and securities comprising the endowment and the F. Paul Anderson Funds were verified by direct communication. Also, the interest earned thereon was accounted for.

RESEARCH FUND

There is included also as part of this report a Balance Sheet showing the Financial position of the Research Laboratories as of the close of business December 31, 1941 as well as a statement of income and expenses and a Budget Comparison reflecting the operations from the calendar year 1941.

Respectfully submitted,

Frank G. Tusa, (Signed)
Certified Public Accountant.

BALANCE SHEET

American Society of Heating and Ventilating Engineers

New York, N. Y.

December 31, 1941

ASSETS

SOCIETY			
CASH			
On deposit	$53,175.91		
Out for collection	18.00		
On hand for deposit	52.14		
On hand	100.00	$53,346.05	
In closed bank		418.97	$ 53,765.02
RESERVE FUNDS			
Cash on deposit			11,353.04
INVESTMENTS (AT COST)			
Securities (Market Value $19,431.00)		18,074.06	
ADD: Accumulated interest	1,200.00		
Accrued interest	37.50	1,237.50	19,311.56
CERTIFICATE OF INDEBTEDNESS		190.03	
ADD: Accrued interest		2.28	192.31
ACCOUNTS RECEIVABLE			
Membership dues	13,571.71		
LESS: Reserve for doubtful	7,501.54	6,070.17	
Advertisers and sundry debtors	29,989.35		
LESS: Reserve for doubtful	1,291.37	28,697.98	34,768.15
INVENTORIES			
Transactions—Copies	2,520.80		
Transactions—Paper	626.72	3,147.52	
Emblem and certificate frames		231.63	3,379.15
PREPAID TRAVELING			
Railroad scrip			3,212.05
PERMANENT			
Library		300.00	
Furniture and fixtures	2,650.96		
LESS: Reserve for depreciation	946.57	1,704.39	2,004.39
			$127,985.67
SPECIFIC FUNDS			
ENDOWMENT FUND			
Cash on deposit	$ 6,985.51		
Cash on hand for deposit	202.50	$ 7,188.01	
Securities at cost (market value $16,236.40)	$19,418.65		
ADD: Accumulated interest $250.00			
Accrued interest ... 78.96	328.96	19,747.61	26,935.62
F. PAUL ANDERSON FUND			
Cash on deposit			1,163.08
			$156,084.37

LIABILITIES AND GENERAL FUND

SOCIETY		
ACCOUNTS PAYABLE		$ 9,888.22
DUE RESEARCH FUND		
On dues as and when collected	$ 5,016.55	
For equipment purchased	187.12	5,203.67
ACCRUED ACCOUNTS		
Compensation—Secretary and staff		3,085.22
DEFERRED INCOME		
Members dues	9,126.72	
Proposed members dues	308.63	
Guide advertisements	2,650.00	12,085.35
RESERVE FOR PUBLICATIONS		
TRANSACTIONS—Volume 46	3,900.00	
TRANSACTIONS—Volume 47	3,700.00	7,600.00
TOTAL LIABILITIES		37,862.46
GENERAL FUND		
Society		90,123.21
		127,985.67
SPECIFIC FUNDS		
ENDOWMENT FUND		
Principal	24,063.28	
Unexpended income	2,872.34	26,935.62
F. PAUL ANDERSON FUND		
Principal	1,000.00	
Unexpended income	163.08	1,163.08
		$156,084.37

NOTE "A": This Balance Sheet is subject to the comments contained in the letter attached to and forming a part of this report.

BUDGET COMPARISON

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

For the Year Ended December 31, 1941

INCOME

	Actual	Budget Provision	Increases Decreases
Initiation fees	$ 1,970.00	$ 1,200.00	$ 770.00
Membership dues	31,633.60	25,000.00	6,633.60
Editorial contract	15,999.96	16,000.00	.04
Profit—Emblems and frames	63.60	200.00	136.40
Profit—TRANSACTIONS, reprints, etc.	77.37	200.00	122.63
Interest from savings bank and securities	949.47	1,000.00	50.53
Sales of GUIDES	19,910.50	18,000.00	1,910.50
Guide advertising	27,046.72	24,000.00	3,046.72
International exposition	1,945.95	–0–	1,945.95
TOTALS	$99,597.17	$85,600.00	$13,997.17

EXPENSES

GENERAL SOCIETY ACTIVITIES

Meetings	$ 2,503.00	$ 2,000.00	$ 503.00
Chapter allowances	1,000.00	1,200.00	200.00
Membership promotion	246.05	300.00	53.95
Speakers' bureau	1,408.45	1,500.00	91.55
HPAC Subscriptions	5,828.00	6,000.00	172.00
Postage	1,820.69	1,800.00	20.69
Rent and light	3,612.46	3,625.00	12.54
TRANSACTIONS	3,906.21	2,500.00	1,406.21
Codes	–0–	1,000.00	1,000.00
Salaries	18,156.00	18,000.00	156.00
General printing	491.97	500.00	8.03
Awards, membership certificates, etc.	231.54	200.00	31.54
President's fund	1,546.45	1,800.00	253.55
Secretary's travel	1,304.75	1,000.00	304.75
Council and chapter delegates travel	4,362.64	4,500.00	137.36
Bank charges	108.62	100.00	8.62
Multigraphing and address changes	525.75	400.00	125.75
Telephone	638.02	400.00	238.02
Telegrams	180.34	200.00	19.66
Professional services	575.00	600.00	25.00
General office expense	611.66	500.00	111.66
Office supplies	585.78	500.00	85.78
Furniture and fixtures	246.38	200.00	46.38
Reserve for additional compensation	3,085.22	3,250.00	164.78
Research appropriation	5,000.00	5,000.00	–0–
Special appropriation	100.00	245.00	145.00
Research booklets	890.04	750.00	140.04
GUIDE EXPENSES			
Paper	3,416.41	3,000.00	416.41
Printing and binding	14,491.56	13,300.00	1,191.56
Express and mailing	5,151.45	3,500.00	1,651.45
Engraving and art work	693.54	500.00	193.54
Advertising sales promotion	1,687.95	2,000.00	312.05
Copy sales promotion	3,144.92	3,000.00	144.92
Editorial and advertising salaries	5,199.95	6,000.00	800.05
Committee expenses	342.61	480.00	137.39
Yearbook	1,417.31	1,500.00	82.69
	35,545.70	33,280.00	2,265.70
TOTALS	$94,510.72	$91,350.00	$ 3,160.72

BALANCE SHEET

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS
RESEARCH FUND—New York, N. Y.
December 31, 1941

ASSETS

CASH			
ON DEPOSIT			
Treasurer's account—Bankers Trust Co.	$1,850.10		
Secretary's account—Chase National Bank	2,571.76		
Director's account—Forbes National Bank	401.41		
Thrift account—Bank for Savings	3,252.16	$8,075.43	
ON HAND FOR DEPOSIT			
Treasurer's account—Bankers Trust Co.		6,074.75	
ON HAND			
Petty cash—Pittsburgh, Pa.		45.47	$14,195.65
ACCOUNTS RECEIVABLE			
AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS			187.12
CLAIM RECEIVABLE			
Navy Contract No. 66853			2,500.00
WORK IN PROGRESS			
Navy contract			3,354.94
PREPAID TRAVELING			91.15
PERMANENT			
Laboratory equipment			1.00
TOTAL RESEARCH FUNDS			$20,329.86
RESEARCH ENDOWMENT FUND			
CASH ON DEPOSIT			
Bank for Savings		544.89	
Bank of U. S. in Liquidation		167.78	712.67
			$21,042.53

LIABILITIES AND FUNDS

DEFERRED INCOME			
PROJECTS			
Summer cooling	$1,859.45		
Glass study	1,088.38		
Corrosion	525.00		
Convectors	300.00	$3,772.83	
DUES—Members and Associates			
40% of 1942 dues prepaid in 1941		5,330.00	$ 9,102.83
ACCRUED ACCOUNTS			
Professional service			100.00
RESEARCH FUND			11,127.03
TOTAL RESEARCH LIABILITIES AND FUND			20,329.86
RESEARCH ENDOWMENT FUND			
Principal		600.00	
Unexpended income		112.67	712.67
			$21,042.53

NOTE "A": This Balance Sheet is subject to the comments contained in the letter attached to and forming a part of this report.

NOTE "B": The Research Fund as at December 31, 1941 had a contingent asset amounting to $5,016.55 arising from 40% of the Society's members' and associates' dues, payable upon collection by the latter.

BUDGET COMPARISON

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

RESEARCH FUND—New York, N. Y.

For the Year Ended December 31, 1941

	Actual	Budget Provision	Increases Decreases
INCOME			
ASHVE dues	$17,987.22	$15,000.00	$ 2,987.22
ASHVE appropriation	5,000.00	5,000.00	.....
Exposition	5,033.10	5,033.10	.....
Interest	48.34	60.00	11.66
CONTRIBUTIONS			
General	2,836.00	2,500.00	336.00
Earmarked:			
Cooperative institutions	1,165.55	3,090.00	1,924.45
Navy contract	20,000.00	25,000.00	5,000.00
Radiation and comfort	935.00	1,400.00	465.00
Floor losses	1,000.00	1,000.00	.....
Glass study	3.75	1,600.00	1,596.25
TOTALS	$54,008.96	$59,683.10	$ 5,674.14
EXPENSES			
COOPERATIVE INSTITUTIONS	$12,775.30	$12,800.00	$ 24.70
PITTSBURGH LABORATORY			
Navy contract	20,000.00	25,000.00	5,000.00
Radiation and comfort	3,495.15	3,400.00	95.15
Basement heat losses	994.84	1,000.00	5.16
Glass study	3.75	1,600.00	1,596.25
Air conditioning in industry	4,018.95	4,500.00	481.05
Duct friction	1,312.60	1,500.00	187.40
Cooling load	3,557.03	3,500.00	57.03
Heating load	3,096.04	3,000.00	96.04
INSTRUMENTS AND EQUIPMENT	1,689.23	2,000.00	310.77
TOTALS	$50,942.89	$58,300.00	$ 7,357.11
Excess of income over expenses	3,066.07	1,383.10	1,682.97
TOTALS	$54,008.96	$59,683.10	$ 5,674.14

A. V. Hutchinson gave the report of the Secretary.

Secretary Report

During the year 1941 the Secretary's office has carried on the administrative duties required by the Constitution and By-Laws of the Society. All details of the financial transactions will be given in the Treasurer's report. Those relating to the production of THE GUIDE 1942 will be outlined in the report of the Guide Publication Committee and other special committees will tell about the progress of their respective assignments.

The 1941 Annual and Semi-Annual Meetings were held at greater distances from headquarters than previous meetings of the Society and imposed a heavier load on the office staff in order to carry out the necessary preparations. Plans also had to be made for handling two expositions and the show held in San Francisco was considered an outstanding success. Unfortunately, the last minute cancellation of the Philadelphia Exposition required meeting program revisions and the necessity of issuing special publicity matter to members.

Due to the speeded-up program of Research, a greater number of papers have been developed this year than in a similar period in the past, so that the Publication Committee's work was greatly increased, but through the cooperation of Chairman P. Nicholls and his associates all essential requirements have been met in reviewing and printing the technical papers.

THE GUIDE has been enlarged somewhat and is being issued with a stiff binding in order to make a stronger and more useful volume. The mailing to members is being started during the week of January 26 and distribution should be completed by February 15.

Although some increase in membership was recorded a great many members have entered the military or naval services and many more have been engaged in emergency construction work so that the problem of keeping up with changes of addresses for members has been quite difficult in the past few months. Some trouble has been experienced in locating members whose mail was returned because they failed to notify the headquarters office of change of business or home address and left no forwarding address with the postal authorities.

The employment service was another phase of the work which has been in much greater volume this year than in former years. A great many placements have been made and there has been a constant demand from government agencies and firms engaged in defense work for experienced engineering personnel. In general, members of the profession have enjoyed a very prosperous year and this has been reflected in early dues collections.

A new method of providing speakers for Local Chapters was tried this year by the Local Chapters Committee and it was easier to handle and at the same time provided better service to the Chapters as they could depend upon definite dates for speakers. The Secretary was privileged to assist many of the Chapters in planning their meetings programs for the fall season and was able to visit 24 Chapter cities during the year.

Membership activities have been in good volume and during the year a new form of membership application was approved by the Council and is now in use. Each member received a copy recently with a new booklet describing the Aims and Activities of the Society. Earlier in the fall an outline of research activities was submitted to each member in a special booklet prepared by the Committee on Research.

Two volumes of TRANSACTIONS are now in preparation and Vol. 46 (1940) is being printed and will be ready for distribution within 60 days. This will be followed closely by Vol. 47. The Council requested that members be polled regarding their

MEMBERS COMMITTEE ON RESEARCH

ELECTED FOR 1942

Three-Year Term

C. F. Boester
St. Louis, Mo.

W. E. Heibel
New York, N. Y.

J. A. Goff
Philadelphia, Pa.

C. A. McKeeman
Cleveland, Ohio

C.-E. A. Winslow
New Haven, Conn.

desire to have TRANSACTIONS and the return cards indicated that 75 per cent of the members desired transactions and filed their requests within the specified limit date.

It should be noted that the varied activities of the headquarters office were carried on without increase in staff during the past year and also that one half of the time of the Technical Secretary is devoted to the work of the Committee on Research. It is my desire to express appreciation for the splendid cooperation of the Officers and Committee Members who have served this year and to pay tribute to the fine work of the headquarters office staff.

Respectfully submitted,

A. V. HUTCHINSON,
Secretary.

Prof. C.-E. A. Winslow was called upon by President Fleisher to present the report of the Committee on Research. Prof. Winslow, Vice Chairman of the Committee, gave a detailed report of the activities and outlined the problems now being studied at the Research Laboratory in Pittsburgh and at the Cooperating Institutions. The complete report will be published in a forthcoming issue of the JOURNAL.

In the absence of Prof. C. M. Humphreys, C. S. Leopold, Member of the Guide Publication Committee, presented the report.

Report of the Guide Publication Committee

Work on the 20th edition of the HEATING, VENTILATING, AIR CONDITIONING GUIDE 1942 was started when the Guide Publication Committee held its organization meeting on March 8, 1941. Two additional meetings were held during the spring and summer. In the preparation of this GUIDE, the Committee has endeavored to present the latest available authoritative information on the various subjects covered in the 47 Chapters. In accordance with the policy established by its founders, approximately one-half of the GUIDE chapters have been reviewed. Of these, nine were completely rewritten and minor revisions were made to nine others.

A new chapter entitled Fundamentals of Heat Transfer has been added which includes the basic equations for conduction, convection, and radiation. A detailed solution is given for a problem involving all three mechanisms of heat transfer. Except for the insertion of this chapter, there has been no change in the order of subject presentation.

Some revisions have been made in the text of the chapter on Thermodynamics of Air and Water Mixtures. The Mollier Diagram for Moist Air, which first appeared in the GUIDE 1941 has been redrawn and a new Volume Diagram for Moist Air has been added.

The chapter on Central Systems for Comfort Air Conditioning has been completely rewritten, and the revision of the chapters on Air Distribution, Air Duct Design, Sound Control, Fans provides new data on the design of air handling systems. The new air friction chart developed by the ASHVE Research Laboratory is included in the Air Duct Design chapter. The chapter on Radiant Heating has undergone major revisions, and now contains the essential data necessary for the design of radiant heating systems.

In addition to the chapters mentioned above, the following were also reviewed and revised: Physiological Principles, Combustion and Fuels, Automatic Fuel Burning Equipment, Radiators and Convectors, Pipe, Fittings, Welding, Heat Transfer Surface Coils, Spray Equipment, Air Pollution, Air Cleaning Devices, Natural Ventilation, and Water Supply Piping and Water Heating.

The Technical Data Section of the 1942 GUIDE contains 856 pages, an increase of 48 pages over the previous issue. This increase was made absolutely necessary by the addition of new and important material.

The Catalog Data Section contains valuable and concise information on many types of equipment. It has been carefully arranged in logical sub-divisions to facilitate its use.

The 1942 GUIDE is the result of the unselfish work of many individuals over a period of 20 years. In recognition of this fact, the Guide Publication Committee wishes to thank the many contributors to the earlier editions of the book. We also thank the many GUIDE users who have offered helpful suggestions, and those who assisted the Committee in reviewing and editing the GUIDE material. Special thanks are due those who have contributed the new material which appears in the 1942 GUIDE. Their names are included in the Preface.

The Committee also wishes to acknowledge the excellent work of John James, Technical Secretary of the Society. His expert guidance and judgment were invaluable.

As Chairman, I wish to thank the other members of the Committee who so willingly devoted their time and energy to the task of producing a new GUIDE.

In closing, the Committee is glad to announce that many GUIDES are already completed and are now being distributed. We hope that the 1942 GUIDE may prove as useful as its predecessors.

Respectfully submitted,
CLARK M. HUMPHREYS, *Chairman*

Joe Wheeler, Jr., Chairman of the Board of Tellers, gave the result of election of Officers and the Committee on Research:

Report of Tellers

Ballots for Officers

President—E. O. Eastwood 750
1st Vice-President—M. F. Blankin 733
2nd Vice-President—S. H. Downs 746
Treasurer—E. K. Campbell 743
Members of Council—L. G. Miller 748
A. J. Offner 745
A. E. Stacey, Jr. 751
B. M. Woods 750

Scattering Votes for—*1st Vice-President:* W. E. Heibel, A. P. Kratz, A. J. Offner, J. H. Walker and C.-E. A. Winslow.
2nd Vice-President: M. F. Blankin, A. P. Kratz and H. Mathis.
Treasurer: J. F. S. Collins Jr., S. H. Downs, E. N. McDonnell, A. J. Offner, R. J. Tenkonohy and G. L. Tuve.
Members of Council: N. D. Adams, R. E. Backstrom, J. H. Carter, J. Davis, S. H. Downs, James Holt, H. J. Rose and J. H. Walker.

Ballots for Committee on Research

C. F. Boester, St. Louis 751
J. A. Goff, Philadelphia 750
W. E. Heibel, New York 750
C. A. McKeeman, Cleveland 751
C.-E. A. Winslow, New Haven 750
Scattering Votes for—M. S. Wunderlich, G. L. Larson and W. M. Sawdon.

Total Ballots—801; Legal Ballots—751; Invalid Ballots—50.

BOARD OF TELLERS,
Joseph Wheeler, Jr., *Chairman.*
Harry H. Bond,
Charles R. Hiers.

H. H. Erickson, Chairman of the Committee to Study Method of Selecting Society Officers and Council Members, presented his report which had been mailed to all members on January 14, 1942. Accompanying the report was an Amendment to Article B-VIII, Sec. 11 of the By-Laws offered by petition in accordance with Art. B-XVI, Sec. 1 of the By-Laws, copy of which had been mailed to all members under date of December 24, 1941. President Fleisher said that a discussion of the Committee's recommendations would be welcomed after which

a vote would be taken upon the proposed Amendment to the By-Laws.

W. H. Driscoll, Syracuse, said that the Committee had studied many methods which it considered would improve the prevailing plan of Nominating Officers and Council Members. He said that every national scientific organization and all those in closely related fields selects its Nominating Committee by substantially the method proposed in the Amendment.

F. C. McIntosh, Pittsburgh, said that he approved the principle on which the Committee acted but considered that the amendment was defective and should have been submitted to the Committee on Constitution and By-Laws at least informally before it was circulated to members.

R. H. Carpenter, New York, commented on two points —the fact that over one-third of the membership did not have or want any Chapter affiliation and that the matter of expense was an important factor as the number of Chapters increased. He thought that the lack of representation by a large portion of the membership and the drain on the Society's treasury made a change in the Nominating Committee essential.

Albert Buenger, Cincinnati, said that he would like to bring out the fact that the present method of nomination resulted from a desire some years ago of Western chapters to have a stronger voice in Society affairs, and that his service on the Council convinced him of the absence of any sectionalism or chapter favoritism because Council members served for the benefit of the entire Society. He considered the present method cumbersome and thought that the special committee's suggestions should be adopted.

T. D. Stafford, Grand Rapids, said that he received no notification that the question of By-Law amendment would be considered at the meeting and he thought that the matter should be tabled.

President Fleisher said that the amendment and the report were mailed to individual members, not to Chapters, and asked for a show of hands of those who received a copy in advance of the meeting. (The majority of those present raised their hands.)

R. A. Miller, Pittsburgh, said that the present Amendment would in principle have his approval, but it would seem appropriate to refer the matter to the Committee on Constitution and By-Laws and have it properly presented by them after this discussion.

E. K. Campbell, Kansas City, said that the proposed amendment was similar to the method of nominating used some years ago by the Society and he considered that the present method of the nominating committee had produced highly satisfactory results.

John Howatt, Chicago, gave five specific criticisms of the Committee's report and read a communication prepared by the Board of Governors of the Illinois Chapter which expressed further opposition to the proposed amendment. He considered the change in method of nominating Officers and Council Members so important that it should not be acted upon until every member had a chance to study the matter fully.

L. T. Avery, Cleveland, thought that if engineering is deëmphasized in our Chapters, we will lose our appeal to the membership and if the Chapter is deëmphasized in the National Society, membership strength will be lost.

J. S. Kilner, Detroit, felt there were two distinct sides to the question concerning the importance of the national and chapter representation and he felt that some machinery might be set up where half of the Nominating Committee could be appointed by the Council and the other half by the Chapter Delegates.

C. E. Bentley, San Francisco, expressed opposition to the proposed amendment, especially because of the meeting attendance stipulation which was included among the qualifications for committee membership.

C. Tasker, Toronto, said that members in Ontario were not satisfied with the present method of Nominating and he favored the change outlined in the proposed amendment.

J. W. Brinton, Boston, expressed the opinion of the Board of Governors of the Massachusetts Chapter that they unanimously favored the proposed By-Laws.

J. A. Bishop, Dallas, referred to a communication from the St. Louis Chapter and expressed the opinion that the present method should be retained.

Mr. Adams mentioned the fact that only 700 or 800 members voted for Officers and thought it would be interesting to find out how many of those who voted belong to Chapters. He also thought that the Nominating Committee should be named at the Annual Meeting each year by the members in attendance.

President Fleisher said that it would be necessary to adjourn at 12:15 p.m. for the Get-Together Luncheon, but the discussion could be continued at the afternoon session. He said that the By-Laws require a vote on the amendment at this meeting.

M. C. Beman, Buffalo, said that apparently consideration was being given to two methods of nomination and both were under fire, the present method because of the Committee's report and the Committee's suggestion is being criticized because it recommended substantially what we had once before. He made the suggestion that an entirely different method be substituted and have the Nominating Committee consist of the last five past presidents.

R. K. Becker, Evansville, said that as a non-chapter member he thought that there was room for improvement in the nominating procedure and the proposed plan would let many feel as though they were not total strangers in the Society.

Ferdinand Jehle, Indianapolis, suggested that, since an engineering society is probably no better than its chapters, he thought everyone should be assigned to a chapter and increase the dues to cover the costs involved.

C. F. Boester, St. Louis, said that the members of St. Louis Chapter voted unanimously to oppose the suggested change in the By-Law and he said that *ASRE* members were automatically assigned to chapter districts, so that there was no reason why this same method could not be followed.

A luncheon recess was then taken.

The discussion was continued during the Monday afternoon session, and W. H. Driscoll, Syracuse, said that, no matter what results from this very animated discussion, we all have the utmost respect for the opinions of each other. He said the committee had given long and serious thought to the problem and it had deliberately offered a solution that they considered would cause the greatest controversy. He reminded members that

this matter had been under consideration for three years, that there was dissatisfaction and discontent with the present arrangement, that the question had been much debated, but he thought a solution was in sight. He said that the whole matter had been handled under the procedure outlined by the Society's By-Laws and said the questions involved should be solved according to what the Society wants and it is up to the Society to make its decision.

Prof. C.-E. A. Winslow, New Haven, expressed the opinion that the present system is somewhat unwieldy and thought it would be unwise to press the matter to a conclusion, because it might create an unfortunate reaction. Professor Winslow offered the following motion, seconded by Professor Eastwood:

THAT: The proposed amendment to Article B-VIII, Section 11 of the By-Laws be tabled and that the special Committee's report and the transcript of the discussion from the floor be referred to the Committee on Constitution and By-Laws for consideration and for consultation by letter with the membership of the Society, and that the Committee recommend such appropriate action as it may deem desirable at a date sufficiently ahead of the 49th Annual Meeting to make action possible at that time.

President Fleisher called for a vote on the motion and it was carried.

SECOND SESSION—Monday, January 26, 2:30 P. M.

The first technical session convened at 2:30 p. m., with Pres. W. L. Fleisher presiding. The first paper was presented by F. W. Hutchinson, Berkeley, Calif., which was entitled, Panel Heating and Cooling Performance Studies, by B. F. Raber and Mr. Hutchinson (complete paper published in February 1942 ASHVE JOURNAL SECTION, *Heating, Piping & Air Conditioning*). A prepared written discussion was then presented by:

C.-E. A. WINSLOW, New Haven, Conn. (WRITTEN): I have listened to the paper by Professor Raber and Mr. Hutchinson with great interest and have had the privilege of visiting the laboratory at Berkeley and seeing the experiments in operation.

The authors' theoretical analysis of the factors which determine the effectiveness of re-radiation surfaces is most valuable and should be basic in our thinking about this complex and fascinating problem; and their actual experiments in the reflection chamber demonstrate the practical significance of the procedure. I have been working in this field now for a good many years but nevertheless felt a real thrill on sitting down in Professor Raber's copper booth in cold air and feeling waves of heat come to my face from the cold copper surfaces as a result of re-radiation of my own body heat. The sensation is in kind if not in degree similar to that experienced on opening the door of a furnace, and it gives one a vivid sensation of the efficacy of the human body as a heat source.

I should like to suggest a word of caution in regard to a possible misinterpretation of the results presented. It is quite true, as the authors say, that in a booth of high conductivity and with relatively free circulation of cold outside air within the enclosure, the human body can only keep itself warm in a booth of small size. In an actual building, with any local heated surface, instead of the human body, as the source of radiation, the same general principle applies. With such conditions, however, with heat conductivity reduced to a relatively low level and no considerable inflow of cold outside air, a state of equilibrium is ultimately reached between heat input and heat output. The larger the room, the longer it takes to reach such a state. After equilibrium is attained, however, air and wall temperatures throughout the space approach each other closely. When this occurred the saving effected by re-radiation will still, as the authors have theoretically demonstrated, bear a relation to the size of the room; but the quantitative factors will be such that economy due to the use of surfaces of high radiation-insulating value remains substantial and important.

H. B. NOTTAGE, Hartford, Conn.: I believe the authors should be commended for the method of attack which was used in the analysis. The problem was assumed and next a certain physical system was established and then a hot body placed in it and finally by a simple heat transfer analysis the effects of emissivity were predicted. Later a subject was selected for analysis and measurement, which made it possible for the investigation to verify the preliminary predictions. This sort of procedure is well worth while and I think the results, while they are not final, are a step in the right direction.

L. T. AVERY, Cleveland, Ohio: These tests seem to indicate that in order to make a person feel comfortable with heated air, a wall surface is used having a reflectivity to heat. I would like to inquire how this condition can be reversed when it is desired to use cool air.

MR. HUTCHINSON: This question can be answered by assuming that a room has perfectly reflecting walls. In that event, the occupant during the heating season could not lose energy by radiation to such walls. During the cooling season, if this room was equipped with a 1 sq ft panel having an emissivity of 1.0, then the total cooling load in such a room would consist only of that heat necessary to maintain body comfort for the occupant. If in such a theoretical room perfectly reflecting surfaces were possible and one could maintain optimum summer comfort with a total cooling load of approximately 50 to 60 Btu per occupant, and the number of occupants were double, the cooling load would also double. In other words, the load is a function of occupancy rather than of transmission losses. Hence, in a theoretical case, the system is equally applicable to summer or winter application.

F. C. HOUGHTEN, Pittsburgh, Pa.: This paper discusses two problems which have been of interest to us at the ASHVE Research Laboratory. One of these deals with the effects produced in an enclosure with panel heating and the other is the effect of this radiant energy on a person's feeling of warmth. This paper shows that the effect of radiation or feeling of warmth is given as equivalent to a 1 deg increase in mean radiant temperature being equivalent to a 1 deg decrease in dry-bulb temperature, which is not entirely in agreement with the results obtained at our Laboratory.

MR. HUTCHINSON: When this investigation was started we were not interested in the comfort curve and therefore we utilized such data as were available. It was assumed that comfort could be realized at approximately 57 F air temperature with wall temperature of 85 F. As mentioned in the paper we found that 90.5 per cent of the votes were comfortable. If we had investigated different conditions and our assumptions had been incorrect, then the number of comfort votes would have varied considerably. However, the data obtained seem to justify our theoretical conclusions. This study was not an attempt to investigate the comfort curve, but simply to work with assumed data and determine whether the principle of reflective surfaces would operate.

W. L. FLEISHER, New York, N. Y.: Will you please amplify your statement that the so-called panel heating system is no more essential to obtain the results reported in your paper than other methods of heating?

MR. HUTCHINSON: The test rooms used for this investigation did not have any panels installed, but the inside surfaces were made of reflective material. The only heat supplied was by the test subject placed in the enclosure who artificially maintained the ambient temperature due to heat loss from the body. The copper shield, or test enclosure, could have been taken outdoors where the air temperature was approximately 40 F and the subject placed in it and allowed equilibrium temperature to

be realized. In effect, we had no heating system of any kind except that of the human body. The important point to remember is that in such a room if the air temperature is brought up to 57 F by means of a radiator or convector equally good results could be obtained.

W. R. RHOTON, Cleveland, Ohio: I am interested in this particular subject because some of these principles were used in designing the notorious bed which you have heard me previously talk about. In this application mirrors were placed on the inside and while sleeping it was found that under such conditions it was not necessary to supply heat, but actually supply cooling to produce comfortable conditions. I think there are sufficient data available at the present time for most engineers to design a radiant heating system not only for comfort but for various types of industrial applications.

C. F. BOESTER, Lafayette, Ind.: At the present time we are doing quite a lot of work on this subject at the University of Purdue in cooperation with Dr. C. A. Mills of Cincinnati. We are now equipping a six-room residence to work out some of the theories that are outlined in this paper. Several techniques have been developed for obtaining surfaces of high reflectivity, including some special plastics that can encase evaporators so that fractional horsepower refrigeration equipment can place a cycle in reverse during the summer. Different devices for producing heat radiation in the winter have been studied, including methods of diffusion so that regardless of the location of the individual there will be a balance of heat loss produced. At the present time we feel that the air inside the room should be about the same temperature as the outside air. For instance, if it is 0 outside today it might logically be desirable to have 0 temperature inside the room to offset any body loss by convection, etc. We would add radiant energy with primary control being obtained with reflective surfaces.

P. NICHOLLS, Pittsburgh, Pa.: This paper strikes me as a study concerned with saving heat to the body by radiation instead of by clothing, and consequently, one might wear lighter clothing in a house which is equipped with radiant surfaces.

E. M. MITTENDORFF, Chicago, Ill.: Is there any reason to assume from these tests that if the same surfaces were used in the floor and the ceiling the same results would be obtained?

MR. HUTCHINSON: The important factor is not where the surface is, but the resulting equivalent surface emissivity of the entire structure. We were working with an equivalent inside emissivity of 0.025. If a ceiling reflective surface is added to a room and the wall is of non-reflective surface then the equivalent emissivity would be quite high.

J. B. FULLMAN, Pittsburgh, Pa.: Recently I was asked about a room 20 x 30 x 10 ft high, lined with galvanized sheet steel, and the question arose as to whether the size of that room would be such that the number of reflections would offset any reduction in air temperature made possible by the reflection of heat back to the body, or whether comfort would be obtained with a much lower air temperature than would be the case if the surfaces were of ordinary wall board. What would your opinion be as to the effective reduction in air temperature resulting from that structure?

MR. HUTCHINSON: A partial answer to this question could be obtained by calculation and I will be glad to help Mr. Fullman obtain the answer desired.

The next paper presented was entitled Radiation as a Factor in the Feeling of Warmth in Convection, Radiator and Panel Heated Rooms, by F. C. Houghten, Carl Gutberlet and E. C. Hach (complete paper published in December 1941 ASHVE JOURNAL SECTION, *Heating, Piping & Air Conditioning*), and was presented by Dr. Houghten.

MR. FLEISHER (WRITTEN): This paper brings to a head my continual criticism of curves between statistical points, establishing a line of expectancy. It seems to me that in almost every case I have observed over the last 20 years, the salient facts in connection with the establishment of comfort zones and comfort lines have been lost in an attempt to interpret individual reactions as determining a group trend.

In this particular investigation a line has been drawn between the points expressing the sensations of warmth or coolness of individual subjects. At the point selected as optimum, along the so-called "4" line half the subjects were slightly cool and half were slightly warm. Not a single subject was ideally comfortable, and half had diametrically opposite sensations from the other half. If that is not interesting from a physiological and psychological angle, I cannot imagine any observations that are, but I certainly cannot see how anyone can draw from these observations the conclusions that that particular point or line or zone is the comfort zone. Maybe the subjects are not very uncomfortable, but they are not ideally comfortable and, more important than that, they have almost exactly opposite sensations. The pertinent question is, why these subjects have exactly opposite sensations and how can we measure physically the differences that develop these opposites.

It is up to us and the medical fraternity and the physicists to find out in what way these people differ fundamentally, skin area, surface moisture, normal temperatures, skin temperatures, metabolism of each of the subjects, then an orientation of his physical measurements to his sensation, and probably some great discovery.

The trouble is that we are measuring and predicting with a yard stick something we should be investigating with a microscope. When we arrive at a critical point where everyone is too cool or too warm, we have the limiting points in our integration that may make it possible to determine the discrepancies at the intermediate points.

We have a great series of observations that show that at 79 deg ET no one feels comfortable, and we have a similar point or line at 64 deg ET. Between these points we have expressions of comfort or warmth or coolness on both sides of the line. If our measurements are to be exact, we would have to have nude subjects, or we would have to know much more fully than we now do the effect of clothing or the materials of clothing. Not only that, we would have to know from individual subjects the effect of clothing on different parts of the body.

In a paper that the Fleishers presented to the Society, we tried to establish the reactions of human beings as a function of the kinetic energy coming in from the enveloping space and to show that at 99 deg, plus or minus, at 0 deg relative humidity, corresponding to the blood temperature no one was comfortable unless his normal blood temperature was above the so-called normal of 98.6 F.

I feel that we have done enough drawing of lines or bands or curves, and with the vast amount of data now available we should retrace our steps and attempt to draw conclusions only from the individual and not from the mean reaction of the group.

J. C. FITTS, New York, N. Y.: It seems to me that in this investigation, the Research Technical Advisory Committee on Radiation and Comfort has been doing some pioneering work. We did not offer this paper as a finished product, but rather as a second installment of an exploratory study. I am not entirely sure that the Society has reached the point where we can define in definite terms the effect of radiation on the environment of an individual in a room, but I think we are approaching much closer to the answer.

The work that Mr. Hutchinson has presented and the study that has been reported covering work done at the ASHVE Research Laboratory are both planned to obtain fundamental data. We realize that there are a number of factors that must still be investigated at the Pittsburgh Laboratory and in the other cooperative institutions, but if the membership will take these two papers as another step to connect up the environment with comfort, I think you will feel that the Society Laboratory has

accomplished something that is worth while and has laid the foundation for more study that will be of great value.

DR. WINSLOW: I think this is a most admirable study, but after all, in discussion it is the point of difference that is important. The major point of difference here is that Professor Raber and Mr. Hutchinson have found, as we have in New Haven, that under a certain set of conditions the lowering of one degree of mean radiant temperature will require a raising of one degree of air dry-bulb temperature, while Dr. Houghten's results are notably different. It is important to remember that this relation varies with the rate of air movement which must be taken into account because any increase in air movement increases the heat loss by convection and does not, of course, have any effect on the radiation characteristics of the space.

I am not quite sure from the analysis of the figures presented that the discrepancy is as great as is indicated. It is a little confusing to use effective temperature in this particular computation but I note from Dr. Houghten's tables that the equivalent comfort conditions averaged about 72.3 for radiant heating and 73.4 for the other type of heating. In each case the average has been determined from the figures presented, all of which seem to tend to substantiate the one to one comparison for mean radiant and dry-bulb temperature.

I think it would be important to analyze a little more thoroughly the curves from which the three to one conclusions have been derived. This is a matter which has been brought up before in these meetings. The points on these graphs are quite highly scattered and I believe I should have drawn the lines quite differently. I notice that Dr. Houghten said that the points did not fit the curves. I think the question to raise is whether the curves fit the points.

MR. HUTCHINSON: I think these two papers bring out the point quite often overlooked. The work at the University of California aside from the particular paper which I presented, has largely been theoretical, whereas Dr. Houghten's work at Pittsburgh has largely been in the collection of experimental data and frequently the two come very close together. Taking the result of Dr. Houghten's paper that the depression of the mean radiant temperature minus the air temperature was around 0.9 F; these check within the 10 per cent of theory. I would not have made that statement a couple of hours ago, but checking with the experimental data we find that it corresponds very closely with the equations.

The data from the experiment which has been reported was based upon the ventilation rate of less than one air change per hour in a room having an equivalent over-all heat transfer factor of 0.20. For example, in a particular panel-heated room of an office building, we think now that we can show that the depression is equal to a direct function of any temperature difference.

The theory indicates that the depression increases rapidly with ventilation rate and also varies as a function of the type of construction. This latter effect is evidenced by the difference between English data based on office buildings and United States data collected largely from residential type buildings. Obviously, a room in a large structure having small exposure has a much lower equivalent conductance.

The point I want to make is that Dr. Houghten's results check quite closely with theory and if this is more than a coincidence then it would indicate that the depression value could be much greater for different types of construction.

DR. HOUGHTEN: The only point that seems to require further amplification is the question raised by Dr. Winslow, regarding the points and the curves drawn through them. It is impossible to obtain a curve that will fit all of the points, and particularly has this been true in all our physiological studies. The best that can be done is to take some kind of a statistical average. The determination of this relationship between mean radiant temperature on the one hand and the effective temperature on the other is based a little more than on these curves for it involves some of Bedford's work.

We are not altogether in agreement with Bedford's studies at high temperatures, which related the effective mean radiant temperature to dry-bulb temperature. However, we have a relation between dry-bulb temperature and effective temperature, which allows us by our close comparison to take the two into account.

There is relatively little difference between Bedford's earlier findings in higher temperatures obtained in industrial work and the results reported in this paper. In the last month we have had occasion to make a comparison of a little different nature, based upon physiological reactions. We have been studying the effect of hot atmospheres on the elevation of body temperature of workers, and in some of those studies the subjects were affected by considerable radiation.

These tests were all made at high temperatures, ranging from 90 to 105 deg ET and in some of the cases we had an elevation of mean radiant temperature above the dry-bulb temperature of as much as 16 F. Hence, we now have curves of the data on rise of body temperature for persons in still air with and without radiant heat and the physiological reactions seem to be the same when you take the dry-bulb temperature in the room with no radiation plus approximately one-half of the elevation of mean radiant temperature above room temperature.

This is a very difficult question to study for the reason that in any of these applications the variation obtained in mean radiant temperature was not great. In the one case with the room in which there was no source of radiation, the mean radiant temperature was at the maximum only as much as 6 deg below air temperature while in the panel heated room it was only as much as 2 deg above.

Vice-President E. O. Eastwood assumed the chair and introduced Dr. Victor Paschkis, New York, N. Y., who presented his paper, Periodic Heat Flow in Building Walls Determined by Electrical Analogy Method (complete paper published in the February 1942 ASHVE JOURNAL SECTION, *Heating, Piping & Air Conditioning*).

C. A. ADAMS, Philadelphia, Pa. (WRITTEN): No engineering problem has been side-stepped more persistently than that of transient heat flow and no other problem has been crying out for solution more vigorously. The reasons for this side-stepping are:

1. The phenomena are very complicated from the theoretical point of view and involve mathematics beyond that available to the majority of engineers.
2. The constants involved are difficult to measure and are often anything but constant.
3. It is very difficult to visualize the phenomena in any quantitative sense, that is to get a quantitative perspective of the problem. Any one who has struggled with the mathematics of these problems and their application to specific cases will appreciate this statement.

There are three methods available for the solution of transient heat flow problems.

(a) The brutally empirical method of experimental measurement connected with a setup which duplicates with fair exactness the conditions surrounding the problem. This method is usually exceedingly difficult and expensive and serves only for the problem in hand. Moreover, the results are often questionable because of the difficulties involved.

(b) *Mathematical Solution*—Even with very simple problems this is not an easy job. In fact, for many of these problems a mathematical solution is impossible except with the aid of very crude simplifying assumptions. Nevertheless, this method is very valuable in developing a quantitative perspective of the relative importance of the major variables involved.

(c) *The Model Method*—Of the two types now available, hydraulic and electrical, the latter developed by Dr. Paschkis is for many reasons superior. It should be noted, however, that even here the degree of complication in the geometry of the problems which can successfully be attacked is limited, although not nearly so much so as is true of the mathematical method.

The problem discussed in the subject paper, being of the parallel flow type is exceedingly simple as compared with very important problems in welding with their high temperatures, more variable parameters and much more complicated geometries.

Nevertheless, since the solution of this type of problem is often so vital to industry, research work in all three methods should be pushed as rapidly as possible by figuring, checking and

rechecking until we have developed a rational method of handling such problems and have developed that quantitative perspective, without which there can be nothing but floundering and expensive industrial mistakes.

It has often happened in other fields that in spite of the mathematical difficulty, rational formulae have been developed in which the coefficients and exponents are determined by experimental research. If in doing this, careful account is taken of the relation of the minor variables to these coefficients, results can often be extended well beyond the range of the experimentation. This is the ideal towards which we should work in this very important field of engineering endeavor.

Finally, I consider Dr. Paschkis' work a very important part of this picture and hope that he will be given all possible encouragement and financial support.

J. R. ANDERSEN, Philadelphia, Pa. (WRITTEN): The two problems of periodic heat flow in building walls discussed in this paper were presumably chosen to indicate the validity of this electric analogy method in the solution of periodic heat flow problems. The author has shown that it is possible to represent electrically all of the essential features of the thermal performance of building walls by a simple electric model circuit.

There are in general three methods which may be applied to the solution of engineering problems (*a*) analytical methods, (*b*) direct experiments on the equipment, and (*c*) model experiments. All three of these methods have their own sphere of usefulness, but each when correctly applied is capable of producing essentially the same information.

Ordinarily the analytical solution of periodic heat flow in walls and slabs is practical only when (*a*) the wall is homogeneous and isotropic, (*b*) when the surface boundary conditions are readily expressible mathematically. The electric analogy discussed in this paper is not subject to these limitations since non-homogeneity and non-isotropy can be built into the model and most boundary conditions can be simulated by manipulation of the model controls.

The two problems considered in this paper are susceptible of analytical solution but the computations would be rather tedious.

The theoretical basis for the electrical model discussed is, as the author points out, the identity of form of the heat flow equation and that of the non-inductive electric circuit. The author neglects to mention, however, that the models described do not strictly conform to that of the non-inductive transmission line as required by the strict application of the electrical analogy, but the model has been simplified by a lumping process for the capacitors. Strictly speaking the models described represent a series of slabs of infinite thermal conductivity but finite heat capacity separated by boundary resistances with no heat capacity. Such a system represents, in the limit as the number of such slabs is increased without limit, the actual thermal problem under consideration. It is fortunate indeed that with the simple models used the performance of the walls under consideration can be so nearly duplicated.

In conclusion the author is to be congratulated on the introduction of this interesting analogy to the ASHVE and further results from this method will be looked for with considerable interest.

A. L. LONDON, Stanford University, Calif. (WRITTEN): The method described by Dr. Paschkis is indeed a very powerful experimental technique for solving thermal conduction transient problems. However, it should also be noted that the behavior of a simple lumped parameter capacity-resistance circuit may be determined analytically. Thus the performance of an idealized lumped parameter circuit consisting of three or fewer capacity lumps can usually be predicted without recourse to experiment. For those thermal systems requiring more than three capacitor lumps for an adequate idealization, analytical solutions are still obtainable by the use of a differential analyzer.[1]

In application of the experimental method the readily obtainable analytical solution of a simple capacity-resistance circuit may be employed to provide a valuable verification of the suitability of the model instrumentation, circuit arrangement, and capacitor characteristics (leakage). For instance, the circuit of Fig. 4 in the paper may be rearranged, employing the same elements, to a single capacity system representing the first approximation of the thermal prototype.

For regular periodic excitation the behavior of this simple system can be readily obtained analytically. A simple sinasoidal excitation, of about the same amplitude and period as to be employed in the model tests, may be impressed on the single capacitor system and the behavior measured by the instrumentation. If the measured behavior compares favorably with that predicted analytically, it may be concluded with reasonable certainty that the four capacitor model, together with the instrumentation, will yield satisfactory results in so far as the idealized model represents the prototype.

For many problems a first or second approximation lumped parameter thermal circuit can be devised, the response of which is conservative from the point of view of the problem in mind. The analytical solution of the simple circuit is in many cases of sufficient accuracy for design purposes. For instance, the problem of five partitions of structural members can be treated as indicated. It is also feasible for some systems to provide two idealized circuits which will in behavior straddle the response of the actual system. Then if the two idealized behaviors are in close agreement it can be concluded that either one is an adequate approximation; and, of considerable importance, some idea of the accuracy of the predicted behavior is thereby obtained. A similar procedure could be employed with the electrical model technique.

L. M. K. BOELTER, Berkeley, Calif. (WRITTEN): The solution of problems by analogy is a powerful weapon. The differential equations of two systems, as well as the boundary and initial conditions, must be similar in order that the two systems be analogous. Thermal and electrical circuits can be designed which are strictly analogous. The analogous variables and system parameters noted in paragraph four of the paper do not represent the only analogous systems; for instance, an electrical circuit consisting of resistance and inductance can be arranged to satisfy all of the conditions for analogy. Incidentally, the word *transient* seems to be gratuitous as used in paragraph 4.

It should be emphasized that the lumped parameter electrical circuit shown in Fig. 1 is only an approximation to the thermal system of distributed parameters shown in the same figure. Electrical circuit analysts have made available many *equivalent* lumped parameter circuits. Finally the contact resistances of the thermal system are not represented in the electrical circuit.

A discussion of the thermal balance under *Procedure* seems to overlook the energy reflected from the walls during the day (which indeed may be small) as well as that radiated from the walls. The last sentence, "After the radiation from the sun ceased, switch *Sw* was opened; and the wall was only in heat exchange with the surrounding air by means of the resistor R_{B-o}" is almost correct, but omits consideration of the fact that the transfer from the wall is controlled by convection and irradiation of the wall by space, nor does this sentence include mention of the radiosity of the surface.

Dimensionless ratios similar to those used to express the periodic (or transient) heat flow through a thermal system may also be written for the analogous electrical system. The latter ratios allow the rapid calculation of the parameters of the analogous system. Fourier's Modulus $\frac{a\Theta}{L^2}$, for instance, becomes Θ/crL^2, where:

a = thermal diffusivity
Θ = time
L = length of thermal system
= length of electrical circuit
c = electrical capacity per unit length
r = electrical resistance per unit length

The heat flow into a thermal system as measured by a heat meter will differ from the actual heat rate, due to the thermal

[1] V. Bush, J.F.I., Vol. 212, No. 4, pp. 447-488, October, 1931.

capacity and resistance of the meter, the contact resistance between the wall and the meter, the difference between the wall and meter emissivities, as well as the distortion of the thermal flow path through the wall. These corrections can readily be computed for a given system-meter application, and will no doubt account for some of the discrepancies.

MR. NOTTAGE: I have two questions regarding the definition of the experimental system which was used here for the analogy. What is the basis for selecting the number of capacitor units that are employed to approximate the actual distributor capacity of the thermal system, and how does this selection affect the accuracy of the measures?

Second, in the electrical model experiment, it appears that the voltage enclosed would vary in certain finite steps, whereas, in the actual thermal system, the temperature potential is some continuous function of time. How does this affect the accuracy of the measurements?

DR. HOUGHTEN: This is a most fortunate development which will greatly decrease our research time to determine heat flow curves for estimating heating and cooling loads. In a later paper it will be observed how laborious our present Laboratory process is and how long it has taken us to supply you with all the present information available. Dr. Paschkis is able to determine from our Pittsburgh Laboratory data in 13 min, results that took us months to accomplish by actual observance.

In a previous ASHVE Research Laboratory paper we presented a series of mathematical analyses which would satisfactorily do this job, but it would take 15 to 20 hours on the part of a good mathematician to produce one of the curves. However, we learned in that study as in any mathematical analysis, it is necessary to feed the proper constants into one end and out of the results would come an answer which is no better than the constants used, and the same thing will apply with the analogy just presented.

Before Dr. Paschkis can use his apparatus to determine the curve for any wall, a constant for all the different factors to go into a wall must be known. The two examples stated in this paper were for homogenous walls, and it remains to be seen how well this same application will apply to more complicated walls, including air spaces. There is no doubt that the electrical analogy method will work, but it will probably take a little more work in cooperation with an experimental laboratory to ascertain how some of the necessary constants should be evaluated and used. Knowing such data we should be able to take a complicated wall, and having the conductivity of the material, the heat capacity of it, the cycle of the temperature imposed on one side, determine the proper values for as many walls as desired.

MR. NICHOLLS: I think that the previous discussers have shown that the method described is correct provided the proper constants have been evaluated. However, Dr. Paschkis' method would have been of little value unless these constants had previously been obtained by experimental work, or by direct measurement. I think he has developed a tool which will have a great number of useful applications. I mentioned this many years ago in connection with high temperature furnace work, where I suggested that in connection with determination of heat loss through a furnace structure, the mathematics were so complicated that it would be impossible to solve each case. At that time we calculated a number of solutions for typical sets of conditions and then anyone desiring to estimate the heat loss from a given furnace structure would be able to determine it by one of these solutions.

With Dr. Paschkis' method a more exact result can be obtained and I believe the Society should cooperate with him to the extent of outlining some investigations which will be of great value to engineers in our profession.

DR. PASCHKIS: In the discussions, two issues are raised repeatedly: (1) the fact that we have applied lumped circuits and the number of lumps (sections); and (2) the influence of correct selection of the constants which are fed in the electric analogue.

Lumping. The fact that the method is using lumped circuits rather than one with evenly distributed resistance and capacitance has been dealt with in a previous publication, quoted in the present paper (Footnote 2). It is obvious that the accuracy of the method is improved with an increase in the number of sections. Fortunately results of reasonable accuracy are obtained with a relatively small number of sections. In one case (of two-dimensional flow), we operated with four sections in one direction and three in the other and obtained results within three per cent of the values found by mathematical analysis. For the experiments dealt with in the present paper, we have used 8 sections. Experiments have been started to determine the necessary number of sections in a more general way.

Constants. The assertion by Dr. Houghten is undoubtedly correct, that if the assumption of the physical constants is incorrect, the results of the experiments will also be incorrect. Because of the uncertainty about these constants, best results will be achieved by combining direct thermal measurements with investigations by the model method. One point should, however, be mentioned in this connection. The rapidity with which experiments are carried out by the electrical method allow the repetition of a test with various values of the constants. In general three such constants are involved: thermal conductivity, specific heat, and boundary conductance. By systematically varying these values in consecutive experiments, the relative importance of each can be determined. Efforts toward more exact knowledge of the constants can be concentrated on the one bearing most on the results.

Stepwise change of voltage (Mr. Nottage): If the steps are taken sufficiently close, the accuracy will be sufficient for practical purposes. For extremely rapid changes, more steps are necessary, and therefore the time scale in the model experiment may have to be changed, in order to allow sufficient time for many steps.

Inductance (Professor Boelter): The general conception is that while electrical capacitance and resistance have their strict analogies in the realm of heat, that is not true for inductance. It would be interesting to learn from Professor Boelter which heat phenomenon he considers analogous to inductance. Film conductance: The resistor R_{n-o} comprises the surface losses by convection as well as by radiation. If necessary the resistor can be made variable in order to represent changes in the over-all film conductance. Dimensionless ratio: Reference is here made to the previous publication, mentioned in the present paper (Footnote 2). Heat flow meter: Theoretically the observations of Professor Boelter are correct. The practical design of the heat flow meter is, however, such that the resulting change in apparent thermal capacity and resistivity of the wall are negligible. This is evident from the various previous investigations by Dr. Houghten and co-workers, comparing direct thermal measurements with mathematical analysis.

Accuracy (Professor London): These remarks are of great theoretical interest. In view of repeated experiments, checking the electric method with thermal measurements and with mathematical results, further proof however does not seem necessary. In most cases, the accuracy of one or two lumps will not be sufficient, thus ruling out mathematical analysis. But even where this accuracy is sufficient, the electrical method will yield more rapid results.

President Fleisher resumed the chair and asked Dr. Houghten to present the last paper on the afternoon's technical session, Heat Gain Through Walls and Roofs as Affected by Solar Radiation, by Dr. Houghten, E. C. Hach, S. I. Taimuty and Carl Gutberlet (complete paper to be published in the May 1942 ASHVE JOURNAL SECTION, *Heating, Piping & Air Conditioning*).

Written and oral discussions were submitted by W. F. Fair, Jr., Pittsburgh, John Everetts, Jr., Pittsburgh, C. M. Ashley, Syracuse, N. Y., and Dr. Paschkis, all of

which will be published with the paper when it is reproduced in the May 1942 JOURNAL.

THIRD SESSION—Monday, January 26, 8:00 P. M.

The second technical session was called to order by President Fleisher, who presented Mr. Thomas Chester, Detroit, Mich., chairman of the Research Technical Advisory Committee on Sensations of Comfort, who gave the paper, Comfort with Summer Air Conditioning (complete paper published in the October 1941 ASHVE JOURNAL SECTION, *Heating, Piping & Air Conditioning*).

DR. R. W. KEETON, Chicago, Ill. (WRITTEN): It was previously pointed out[2] that comfort is an affective state produced in the individuals by sensations of heat and cold induced by stimuli arising from the skin. In attempting to gain knowledge of atmospheric conditions which produce comfort, investigators have used in some instances terms which describe sensations (*cold, cool, slightly warm, warm*) and in other instances terms which describe the affective state (*very unpleasant, unpleasant, indifferent, pleasant, and very pleasant*). It is obvious that when the individual comes into a state of neutrality and is unaffected by his environment, he is comfortable. This separation of sensations from their effects on the individual may at first seem unnecessary, but the significance of the distinction should become apparent later.

Gagge, Winslow and Herrington[3] have found that in the nude subject the skin temperature ranges for pleasantness lie between 92.5 F and 91 F. The zone of unpleasantness was found on either side when the skin temperatures reached values of 87.1 F and 94.5 F. In clothed subjects[4] these investigators found again the sensations of pleasantness to be associated with skin temperatures between 90.8 F and 92.4 F. The zones of unpleasantness were reached with skin temperatures of 87 F and 94.7 F. So they concluded that comfort was best correlated objectively with skin temperature. It has come to be appreciated that a temperature that is comfortable to men is, as a rule, too cool for women and one that is acceptable to women is too warm for men. A physiological basis for this difference has been suggested by Hardy and Du Bois[5], in that women produce less heat in the warmer environments, and in the cooler zones their thicker layer of fat in the subcutaneous tissues furnishes an insulation against cold. More recently Yaglou and Messer[6] have attributed these differences in comfort requirements solely to the type of clothes worn. Thus, when the men were dressed in the women's clothing, they behaved as women in their comfort requirements and chose a warmer atmosphere. In a similar manner, when women were dressed in the clothing of men they preferred a cooler atmosphere. They found that comfort in all but a few subjects was associated with mean skin temperatures between 91.5 F and 93.5 F. The exposed skin temperature was a poor index of comfort and the external temperatures of the clothing bore no correlation to comfort. It should be understood that these experiments apply to subjects who were resting or engaged in minimal work. They were in essentially *steady states* from a physiological viewpoint. The results would not necessarily hold for a subject at work whose heat production was elevated or for subjects whose peripheral vessels were undergoing violent fluctuations necessitated by great thermal exchanges.

If these experiments are confirmed by other investigators, they will explain satisfactorily the difference in comfort standards of the sexes, but they will not prove of much practical value in persuading men and women to adjust their clothing habits for the benefit of the engineer. However, these experiments would give support to the committee's suggestions that a higher effective temperature be used as a standard in the southern part of the United States, and a lower one in the northern part. It is well understood[7] that the people of the South habitually dress in lighter clothes than those in the North. Hence the skin temperatures of the Southerner would be held at the comfort range more readily by a higher effective temperature of the environment. In the North the conditions would be reversed.

Many experiments have been reported which indicate that acclimatization plays an important role in establishing the limits of comfort zones. Some are open to criticism. However, there seems to be little doubt that a correlation exists. The factors responsible for the correlation are not clear. Yaglou and Drinker[8] have noted that the American people prefer indoor temperatures 8 F higher than those reported by Vernon as comfortable to the English people. This difference is attributed partly to character of clothing and methods of heating, and partly to the fact that "the English people become *accustomed to cooler room temperature*". This last statement indicates that the adjustments which lead to comfort have not been made in skin temperatures or the translations of these into sensations of heat or cold, but rather in the manner in which the sensations affect the individual. The assay of affective state, after all, is the objective of comfort studies. By training a person can gradually learn to expand or contract the zone within which he is comfortable. The climate is doubtless an important factor in this training and the adjustment is then attributed to acclimatization. It would seem that the separation of the summer comfort zone into climatic division is warranted on the basis of our present knowledge, and the committee is to be congratulated on this very practical suggestion. It is hoped that with a clearer understanding of the underlying factors the individual's selection of comfortable conditions can be predicted with a high degree of accuracy.

JOHN HOWATT, Chicago (WRITTEN): This paper is admittedly a summarization of research reports and other papers of pertinent interest on the general subject of comfort with summer air conditioning, and so makes little attempt to introduce any new or startling idea to the knowledge on the subject. It is an easily readable account of the progress and findings in the field and because of its readability will bring the facts that had been developed to the consciousness of many new readers.

The suggestion that the United States be divided into four zones from north to south in which effective temperatures of 70, 71, 72 and 73 deg are proposed for optimum comfort in summer is perhaps the only controversial idea introduced in the paper. It is admitted that climatization is a factor in determining optimum atmospheric conditions for comfort so it must be admitted that recognition of this factor must prevail; it must be admitted too that even when allowance has been made for all controllable factors, the field of air conditioning for summer comfort will always be one fruitful in criticism and complaint because the criticism and complaints come from individuals and we cannot hope to air condition for the optimum comfort of each individual. For example, how can room temperatures be maintained that will be satisfactory to a woman wearing six ounces of clothing and a man wearing six pounds, or for persons in the vital, vigorous age bracket of the teen years in the same room with people in the late years of life where fires are already dying out.

The use of effective temperature as a measure in the establishment of optimum comfort conditions in air conditioned space is perhaps as good as any that has been devised; nevertheless there are now many people becoming critical of using such a standard. Recent research presented to our Society through papers has tended to show the little effect relative humidity has in individual comfort provided the range is kept somewhere

[2] ASHVE RESEARCH PAPER—The Influence of Physiological Research on Comfort Requirements. R. W. Keeton, F. K. Hick, N. Glickman and M. M. Montgomery, (ASHVE JOURNAL SECTION, *Heating, Piping & Air Conditioning*, January 1941.)

[3] The Influence of Clothing on the Physiological Reactions on the Human Body to Varying Environmental Temperatures, A. P. Gagge, C.-E. A. Winslow and L. P. Herrington. (*American Journal Physiology* 124: No. 1, 1938.)

[4] Loc. Cit. see Note 3.

[5] Difference Between Men and Women in Their Response to Heat and Cold, J. D. Hardy and E. F. Du Bois. *Proceedings National Academy Science* 26: 389, 1940.)

[6] The Importance of Clothing in Air Conditioning, C. P. Yaglou and A. Messer. (*Journal American Medical Association*. 117: 1261, 1941.)

[7] The Summer Comfort Zone: Climate and Clothing, C. P. Yaglou and Philip Drinker. (ASHVE TRANSACTIONS, Vol. 35. 1929, p. 269.)

[8] Loc. Cit. see Note 7.

between 20 and 65 per cent and relative humidity is one of the factors in the effective temperature scale.

On the whole this paper is a worthwhile contribution to our literature on the subject of summer air conditioning and is written in the style which I personally hope will be used more and more by writers on technical subjects so the papers themselves will be more readable.

DR. WINSLOW: The comfort votes reported in this paper are entirely in accord with physiological studies. For instance, we find that at the lower end of the hot zone, sweat secretion sets in more readily in summer than in winter, in other words, persons have been seasonly acclimated to that situation. At the upper exposure and particularly in dry climates there is an enormous range of adaptation. The ordinary individual in a hot, desert climate, can produce about a pint of water an hour and after exercise in such climates this can be raised to double or treble that amount. These are the phenomena that are reflected in the varying comfort zones.

C. E. BENTLEY, San Francisco, Calif.: We find in areas where it is extremely warm if low effective temperatures are maintained a shock effect takes place which is a point I believe should be taken into consideration.

C. TASKER, Toronto, Ont., Canada: I believe Mr. Chester should be extended a vote of thanks for presenting a paper of this form for it summarizes the work done by the Committee in a very readable form. With reference to Mr. Bentley's comment I would like to state that in all of the studies made, when I was the chairman of the Research Technical Advisory Committee of Sensations of Comfort, we very definitely took the most careful data of the outside weather conditions, because in many of these cases, tests were made by subjects who entered the air conditioning enclosure from the outside.

These reactions were taken immediately upon entering and at frequent intervals for the first half hour and at less frequent intervals for the remainder of the test. Then data were collected again when the individuals left the air conditioned space and their reactions were taken immediately thereafter at regular intervals for a short time after leaving the enclosure.

Therefore, we did collect a lot of information pertaining to entering and leaving shock, but I think all of us realize that this is a wide subject on which there is a great need for more work. I agree with Mr. Chester that we can only hope to set up a band, and I believe that those of us who have been in the work would never dare to suggest that Minneapolis, Washington or San Francisco should always hold a certain effective temperature.

MR. CHESTER: Some time ago our Committee suggested that the Committee on Research provide funds for investigating the question of shock, as this is a question which the air conditioning engineer has to seriously consider. The public looks to the engineer to provide comfort and if in providing comfort and an unfortunate condition results in subjecting people to serious shock, that is something we have to recognize and try to alleviate. The public in leaving a summer air conditioned space go out into the outside atmosphere where they feel as if they are entering an oven. This criticism should not be our most important consideration, because this is merely a recognition of the comfort the engineer has provided. Obviously it is not within our province to attempt to cool off the outside atmosphere, so in my opinion this should be disregarded and we should attempt to alleviate the undesirable shock upon entering an enclosure. In the past it has been suggested that the rooms could be provided, as they are in some places in Washington in the government buildings, with intermediate zones where individuals are not subjected to immediate shock.

With reference to the question by Dr. Keeton about people preferring a higher temperature in this country during the winter than in England, it should be mentioned that this variation is probably due to the difference in wall temperatures maintained in the two countries. For instance, in Chicago, Detroit or New York, the temperature drops to 0 and if you provide 70 F dry-bulb during the winter the inside wall surface temperature is around 40 F. In England where it is 40 F outside and it is common to maintain around 62 F dry-bulb temperature, the interior wall surface temperature is a good deal warmer because it is only 40 F outside. Therefore, the loss by radiation from the skin to the wall is quite different and that together with the difference in clothing worn explains why English people have different conditions for comfort in winter.

F. W. HUTCHINSON: I would like to add one item which may be of interest in substantiating the report of this Committee. Last summer I had occasion to travel by boat to Australia with 600 passengers, most of whom were Americans. We stopped at the Fiji Islands where 400 more British colonials were picked up, who were acclimated to the conditions at Fiji. From the Fiji Islands to Australia it was almost impossible to satisfy the people from Australia and the people from Fiji. The dining room was unbearable at all times, due to the fact that it was either too cold or too hot which is a fact believed to be of interest in connection with this paper. Charles Darwin, in one of his earlier books, mentioned the fact that in passing around Tierra del Fuego he found that when camp-fires were built the English huddled around the fire, whereas the natives, at a distance of 20 ft, were sweating profusely because they were acclimated.

MR. CHESTER: The last remark reminds me of the American who went to Patagonia some time ago. It was not very cold there, but there was a high wind. He was talking to a native who did not have much clothing and he inquired how he could stand the climate. The Patagonian said, "Americans don't wear clothing on face. Patagonian all face."

The next paper presented was entitled, Use of Cold Accumulators in the Air Conditioning Field, by R. W. Evans and C. J. Otterholm, and was given by Mr. Evans (complete paper published in September 1941 ASHVE JOURNAL SECTION, *Heating, Piping & Air Conditioning.*)

H. E. REX, Chicago, Ill. (WRITTEN): Relatively few air conditioning installations have been made utilizing stored refrigeration effect, and possibly all that have employed storage have done so through improvised equipment consisting of tanks, coils of pipe, etc. It is likely that the availability of the accumulator cell described by the authors, together with the load calculation outline, will lend impetus to the storage method for solving many air conditioning load problems.

It would be interesting to have a more detailed description of the method used by the authors for automatic control of ice thickness and for refrigerant feed. It would appear that uniformity of ice thickness during freezing should be practically self-attained due to the appreciable insulating value of ice, at least to the extent of preserving water flow passages. Fig. 2 of the authors' paper indicates that the ice is not melted uniformly during the discharge cycle.

The selection of 24 ton-hours as the capacity of one cell certainly will fit a great many applications. The writer has knowledge, however, of one installation utilizing storage involving a medium size store which would have required about 100 cells, had they been used. On this same store the load followed a weekly cycle, rather than daily. This is perhaps a factor in many applications.

The authors have selected a 6 deg rise through the circulator and suggested the same rise through the air cooling coils. No doubt this was done for convenience in illustrating the data. If the accumulator is fitted with proper baffles, the state of depletion is very nearly determined by the temperature of water returning from the air conditioner, rather than the temperature of supply water. Of course this infers storage by reason of the residual water mass, and not by ice plates. This point prompts the consideration of higher temperature rises than 6 deg at the air conditioner.

The application of appropriate safety factor is important on storage jobs to recognize the unusual day, or succession of unusual days. The exhaustion of the accumulator is rapid, after all ice is melted, due to unusual loads, leaving the user without much of anything until time for recharging is available.

The authors suggest that latent cooling period load from ventilation air be assumed constant throughout the cooling period. In the writer's opinion this leaves room for some error, particularly since this element is usually a sizable part of the total load. It would appear that some method using accumulated total heat values based on typical wet-bulb temperature variations would be in order. Similarly, internal load elements, due to occupancy, lights and appliances, sometime deserve to be integrated as carefully as transmission and sunlight gain, when these go to make a large part of the total and when they are subject to variation from time to time during the day.

D. C. PFEIFFER, Dallas, Tex. (WRITTEN): The article is most complete and contains information which should be of general interest to all interested in air conditioning work, and of particular interest to consulting engineers, owners, and those most interested in efficient and economical operation. The application of *storage* in refrigeration work is old, but its introduction into the air conditioning field is relatively new.

Dallas, Texas, has three large office building installations of storage air conditioning, and operating records have been kept for the past three years comparing the power cost of these three buildings with other typical office buildings having conventional air conditioning systems. The results of this study confirm our early prediction as to the performance of this type of equipment, and certainly prove beyond a doubt that it has a decided place in the air conditioning field.

At the time these installations were being planned cold accumulators of the ice type, such as described in this article, were not available and the leading refrigeration manufacturers were invited to quote on cold accumulators consisting of large tanks containing *several miles* of pipe for the accumulation of ice. While there was nothing new in the art of freezing ice, the question of its melting capacity was uncertain and the increased cost of this type of *cold accumulators* ruled them out in favor of the so called *sweet water* tanks. The operation of these tanks consisted of a large body of city water cooled at night by a conventional water cooling system and used during normal air conditioning operation exactly as described in this article. The principal objection to this type of storage system is the large space required for the tank, and the small package units described in this article apparently answer this difficulty and also provide an efficient means of ice melting by the baffling arrangement.

The question of performance and application is so adequately covered in this article that there is little to be added. Generally speaking, *cold accumulators* should be most applicable for churches, lodge halls and restaurants for short duration of air conditioning loads and have a definite place in the air conditioning of office buildings and department stores for a normal eight to ten hours daily use.

From this article the relative investments required for this accumulator-type system as compared with a conventional direct expansion system can be obtained and possibly the only information which could be added to this discussion is the question of electric rate application and its effect upon the operating cost of the storage versus the conventional system.

Generally speaking, electric rates consist of a demand and an energy component. The particular electric service rate should be carefully analyzed and the storage equipment evaluated in terms of the actual savings in demand charge, considering the added cost for the increased kilowatt-hours necessary in this type of system. For example, if the particular electric service rate has a demand charge of $2.50 per kilowatt per month and in the particular location approximately six months of operation constitute a normal season, then there will be a yearly saving in demand charge of six times $2.50 or $15.00 for each kilowatt less than the conventional system. If this particular application has an energy cost of 1 cent per kilowatt-hour (in the particular step of the rate) the storage system should be charged with an estimate of the additional kilowatt-hours required over the conventional system at 1 cent per kilowatt-hour.

It is apparent from this discussion that the higher the demand charge and the lower the energy charge the greater will be the justification for storage installations. A general rule cannot be given except to compute a daily heat gain curve, thus determining the hours of on-peak and off-peak operation. From this information, together with a study of the electric rate, the true economics of storage installations can be determined.

S. R. LEWIS, Chicago, Ill. (WRITTEN): This paper gives intelligible and helpful suggestions to any one needing data on the undoubtedly beneficial process of accumulating a reserve of refrigerating effect during off peak hours. In many air conditioning plants, particularly for theaters and churches, a reduction in the investment and operating costs is practicable by operating the condensing unit longer hours and thereby reducing the size and the power demand charge. Where a large reservoir of chilled water is employed the problems of space occupied, of insulation and of baffling the water within the storage tank are often serious.

This paper provides a background for the whole computation and the accumulators appear to be very compact and are easily insulated.

I think the new terms *accumulated degree hours* and *accumulated sun intensity values* are a contribution to simplification of the rather abstruse thinking which must accompany a design for stored refrigerating effect.

K. C. PORTER, Chicago, Ill. (WRITTEN): The authors of this paper had the rare opportunity of presenting a device which is interesting and useful during ordinary peace time conditions but is doubly useful in the refrigeration and air conditioning field during war time conditions. Since the preparation of this paper much of our production machinery has been put on a 24-hour basis. In the cold accumulator we have a device which can extend the usefulness of our present refrigeration and air conditioning equipment to 24 hours per day.

The equipment herein described calls for copper plate coils. I have been advised that performance characteristics with steel plate coils are entirely satisfactory. Therefore, equipment production should not be restricted by defense (critical material) needs. Since power restrictions may be expected to be concerned largely with system peak demands, the longer hour use of existing refrigeration and air conditioning equipment should be tolerated because of its off-peak nature.

Section II of this paper which deals with performance characteristics proved to be technically disturbing. For instance, we read that the total cooling effect of this 24-ton accumulator varies from 24 to 33 tons depending upon the final water temperature. Since we ordinarily consider a storage battery and an ice accumulator to have a specific amount of available energy, some explanation of the paradox should be given by the authors.

On page 584, column 1, paragraph 2, the statement is made that "the total ton hour output of one such accumulator, is dependent only upon the temperature of the water to be delivered by the accumulator, regardless of the total water circulation required." Almost directly opposite this statement on page 583, column 3, we see an analysis where one accumulator delivering 40 deg water has a capacity of 25¾ ton hours and two accumulators delivering 40 deg water have a capacity of 26½ ton hours each.

It is my belief that much of the reader discomfort with this paper can be traced to the manner in which the test data were obtained. Although it is recognized by the authors that the air conditioning job must be designed for a fixed water temperature

(between 40 deg and 50 deg) the test data are taken without attempt to maintain constant discharge temperature. It would seem to me that test results obtained with the use of a three-way temperature regulating valve would be much more convincing.

Section III, Calculation of Total Cooling Load—offers some interesting material on the accumulation method. It is unfortunate, however, that the authors' material does not check through with better accuracy. For instance, in column 1, page 588, the authors give an example of the use of tables for the determination of accumulated sun load. Their example shows for wall and roof factors, accumulated Rw at noon to be 52.2 for east exposure and 6.4 for south exposure. The table for 30 deg north latitude (upper left on page 587) shows these noon values to be 52.1 for east exposure and 6.5 for south exposure. Although these errors are inconsequential, they are disturbing to the reader. Since they disrupt the continuity of the reader's thought and harm his confidence in the material, such errors should be avoided.

In conclusion, it is my feeling that the cold accumulator has two markets in the war air conditioning picture.

1. *Defense Industry:* Here some economy in size of refrigeration machines and peak load power demands may be achieved by designing for average rather than maximum cooling loads. However, as our defense industries go on a 24-hour basis, the economy of the accumulator becomes questionable.
2. *Civilian Comfort:* As the defense program has been taking hold, our ordinary commercial comfort market is taking a rain check for the duration. For the civilian prospect who has been denied a 20-ton full capacity installation, the 10-ton installation (with accumulator) will possibly also be denied, even though his maximum load upon his utility might be halved in this manner.

The greatest usefulness for this type of equipment *for the duration* appears to be in extending the total cooling capacity of present comfort and industrial installations by a 24-hour ice machine operation.

Mr. Howatt (Written): This paper is a timely presentation of factual data on an addition to the equipment available for use in the summer air conditioning field. Cold accumulators have been used in refrigeration work almost from its beginning, in fact the business of the ice man was based entirely upon his ability to distribute accumulated cooling effects. Cold accumulators are now used in connection with air conditioning work but not as extensively or with the same effectiveness as will be possible with the development of a commercial type of accumulator such as is described in the paper.

The purpose of any cold accumulator is to provide cooling effects in off-peak times when the compressor is shut down. The objective should be to, as far as possible, level out the hills and valleys in the compressor load making possible the use of much smaller compressor equipment, equipment that can be used at nearly full load capacity 24 hours per day. On most of the direct expansion jobs in air conditioning at present the compressor unit or units are designed to take care of the peak cooling load condition which may occur for only a few hours and which is always very much greater than the average 24-hour load. The same condition prevails in the selection of boilers to take care of the heating load in winter. The heating equipment, for example, must be designed to take care of outdoor 10 deg below zero temperature, whereas the average for the coldest 24 hours would always be higher. In heating load calculations but little cognizance is taken of the fly wheel action of the building structure in that it serves as a type of heat accumulator.

The design of the cold accumulator in unit form lends itself readily to arrangements to meet various capacity requirements so is flexible enough to give the designer sufficient latitude. It also makes it possible for the designer to adapt the units to available space and should appeal to engineers, contractors and owners.

It would seem from a study of the paper that the accumulators as designed are possible of reasonably accurate rating under prescribed conditions which feature will make it possible for the designer to make his selection from the manufacturers rating tables with the assurance that the performance of equipment in the field will be equal to their published ratings. This is important in the selection of all engineering equipment today.

On the whole it appears the development is timely in our whole national conservation program at this time because the use of cold accumulators will save time, material and money in the manufacture and installation of air conditioning systems.

President Fleisher stated that the next paper was the result of a research project sponsored jointly by the Atlanta Chapter and the Committee on Research of the Society in cooperation with the Georgia School of Technology. Instead of the Atlanta Chapter petitioning the Committee on Research for full financial support of this work the Chapter was successful in raising from local sources approximately one-third of the money to conduct this research, and he thought this a very appropriate thing for the other chapters to consider.

Mr. Hinton then presented the paper entitled, The Effect of Attic Fan Operation on the Cooling of a Structure, by W. A. Hinton and A. F. Poor (complete paper to be published in the April 1942 ASHVE Journal Section, *Heating, Piping & Air Conditioning*). Written and oral discussions were offered by W. H. Badgett, College Station, Tex., S. F. Nicoll, York, Pa., J. H. Walker, Detroit, Mich., J. A Bishop, Dallas, Tex., and E. K. Campbell, Kansas City, Mo., and will be published with the paper in April.

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PRINCETON LECTURER

Walter L. Fleisher, consulting engineer, 475 Fifth Ave., New York, delivered the Brackett Lecture at Princeton University February 17. His subject was Air in Air Raid

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Shelters. Mr. Fleisher is a member of the Advisory Council of the Department of Mechanical Engineering of the University and he served as President of the ASHVE in 1941.

On March 6 Mr. Fleisher is to address the Greater New York Safety Council at Hotel Pennsylvania, New York, on the Control of Abnormal Temperatures and Humidities in Industry.

MEETINGS IN NORTHERN OHIO

February 9, 1942. With 43 members and guests attending, the regular monthly meeting was held at the Cleveland Engineering Society Building, and Vice-Pres. C. M. H. Kaercher presided in the absence of President Schurman.

J. B. Fullman, Pittsburgh, Pa., was introduced, and showed an interesting collection of slides covering the subject of radiant heating in a variety of types of buildings from small residence jobs to much larger industrial plants. Among the slides were several fine pictures of installations showing the various steps from first excavation to final completion. Considerable interest was shown as evidenced by the discussion which followed Mr. Fullman's address.

At the conclusion of Mr. Fullman's talk, W. R. Rhoton gave a brief resumé of his experience and contacts with this subject through the Society's Research Technical Advisory Committee working on this particular type of heating, which was followed by adjournment.

January 12, 1942. The January meeting, also held in the Engineering Society Building, Cleveland, was called to order at 8:00 p. m. The speaker, G. C. A. Hantelman, secretary of the Cleveland Engineering Society, was introduced and gave a very timely talk on the subject of the psychology of the Japanese race. He spent many years in Europe and the Far East, and has been a public speaker on International Relations most of his life. His talk was based on personal experience and on an accumulation of information he has gathered over the past 20 years. A brief abstract from his talk follows:

We can perhaps understand the type enemy we are fighting when we realize that Japan must be dealt with in an entirely different manner than other nations have been dealt with in the past. . . . Never before in world history has a nation so turned against its own benefactor. Japan should have erected all over its land memorials of gratitude towards the United States, because it was our country which lifted them out of the morass of medieval servitude. . . . The culmination of their deceit and ruthlessness was reached when they attacked Pearl Harbor, and the question has been asked so often; why can Japan attack Singapore, Hongkong, Borneo, Luzon, the Philippines, and countless other isolated regions, apparently with numerically superior forces when they have been fighting against China since 1931? The answer goes back to Bushide.

Mr. Hantelman described in detail, at the beginning of his talk, the three philosophies which dominate Japanese life and Bushide was one of those. At the conclusion of his talk he stated:

Our government is recognizing the importance of teaching our soldiers the background of the distorted Japanese philosophy, and once our boys have learned that the only way to battle Japan is by superior strategy and even greater ruthlessness, the rising sun of Japan will set never to rise again.

This interesting talk was followed by a round table discussion of the subject, and the meeting was adjourned at 10:00 p. m., by President Schurman.

WASHINGTON, D. C. HOLDS INTERESTING MEETINGS

February 11, 1942. Attended by 45 members and guests the February meeting was held at the Dodge Hotel. Following the regular order of business and presentation of reports, J. H. Fogg, chairman of the membership committee, reiterated his previous request regarding prospective members.

J. W. Markert, chairman of the program committee, announced that

March Speakers at Chapter Meetings.

J. F. Collins, Jr., Pittsburgh, Chairman of the Chapter Relations Committee announces that 18 Chapters have requested the assistance of the Committee in obtaining speakers for the March meetings. The assignments made are as follows:

Chapter	Name of Speaker	Date
Atlanta	Prof. A. P. Kratz	March 3
Cincinnati	Prof. F. B. Rowley	March 10
Connecticut	M. F. Blankin	March 10
Delta	Prof. A. P. Kratz	March 5
Golden Gate	Prof. E. O. Eastwood	March 4
Iowa	S. H. Downs	March 12
Kansas City	S. H. Downs	March 9
Manitoba	M. S. Wunderlich	March 18
Massachusetts	Dr. M. B. Ferderber	March 17
Montreal	M. F. Blankin	March 16
Nebraska	S. H. Downs	March 10
New York	Dr. M. B. Ferderber	March 16
North Texas	S. H. Downs	March 7
Oklahoma	S. H. Downs	March 4
Philadelphia	Prof. C.-E. A. Winslow	March 12
Southern California	Prof. B. M. Woods	March 4
South Texas	S. H. Downs	March 6
Wisconsin	Prof. F. B. Rowley	March 9

an *Information Please* session would be provided for the next meeting.

F. E. Spurney gave an informal report on the 48th Annual Meeting of the Society in Philadelphia, and at the conclusion of his remarks, Rutcher Skagerberg, U. S. Housing Authority, talked on the experiments with a typical residential warm air system. He presented some very interesting data on actual operating costs and results of experiments conducted in his own home. His observations were of such interest to the membership he was requested to continue his individual research and report to the Chapter during the next season.

R. S. Dill, National Bureau of Standards, then spoke on residential heating systems during war times. Mr. Dill discussed some of the proposed designs and their relative efficiencies and in general left his audience with the thought that there is still much left to be desired in residential heating design.

January 14, 1942. The January meeting was also held at the Dodge Hotel and was attended by 30 members and guests. Pres. F. A. Leser presided, and following the routine business, J. W. Markert of the Engineering Department of the Maritime Commission introduced the guest speaker, Frank Dehler, who delivered an interesting and instructive talk on silica-gel. He discussed its manufacture, properties and its various uses, and used slides to illustrate his remarks. After a brief period of discussion the meeting adjourned at 10:00 p. m.

INCENDIARY BOMBS DISCUSSED AT SOUTHERN CALIFORNIA

February 4, 1942. The regular meeting of the Southern California Chapter was held at Eaton's Chicken House with 41 members and guests present.

Pres. A. J. Hess opened the meeting and after a short business session, an interesting and enlightening talk was given by Battalion Chief Danks of the Los Angeles Fire Department on incendiary bombs and their control. President Hess then gave a resumé of the 48th Annual Meeting of the Society in Philadelphia, which he attended. He gave a detailed account of the meeting and adjournment followed at 10:30 p. m.

January 7, 1942. The January meeting was also held at Eaton's and 49 members and guests were present when President Hess called the meeting to order.

R. S. Farr was then introduced and gave an enlightening talk on the technical problems involved in the design of permanent type air filters.

He was followed by J. S. Earhart, who spoke on automatic filters, giving the advantages and disadvantages of this type, and a comparison of cost over a period of years as compared to other types of filters. After this discussion a talk on electric filters was given by J. Frank Park.

After the various talks a general discussion was held and many questions were asked and answered. All three speakers are members of the Southern California Chapter, and a vote of appreciation was extended to them by the Chapter.

Guide Committee Invites Members' Cooperation

The Guide Publication Committee appointed by Pres. E. O. Eastwood to compile the 1943 edition of THE GUIDE consists of Alfred J. Offner, chairman, New York, N. Y.; P. D. Close, Chicago, Ill., S. Konzo, Urbana, Ill., C. S. Leopold, Philadelphia, Pa., and G. L. Tuve, Cleveland, O.

The first meeting of the Committee will be held during the early part of March and the Committee is desirous of receiving comments or suggestions from members of the Society for desirable additions or revisions. It is requested that these comments or suggestions be sent to Chairman Alfred J. Offner at 139 East 53rd St., New York, N. Y., not later than April 30, 1942, to insure consideration for the next edition.

Look over the edition just distributed and help the Committee make the 1943 volume a better book.

MINNESOTA MEMBERS MEET

February 2, 1942. The February meeting was held at the Coffman Memorial Union, University of Minnesota, with 32 members and guests present.

R. E. Backstrom and H. E. Gerrish reported on the Annual Meeting at Philadelphia and also discussed plans for the Semi-Annual Meeting of the Society to be held in St. Paul, June 15-17.

The speaker of the evening, L. P. Hanson, engineer, gave a talk on "evaporative cooling as applied today." He covered the fundamentals of evaporative cooling, temperature changes, methods of operation, description of special evaporative cooling equipment on the market today, and a discussion of their advantages and disadvantages as concern the average engineer. Mr. Hanson explained that evaporative cooling today is more widely used than is generally recognized.

HOT WATER HEATING AND PENNSYLVANIA TURNPIKE VENTILATION

January 6, 1942. The regular monthly meeting of the St. Louis Chapter was held at the Candlelight House, St. Louis, with Pres. D. J. Fagin presiding and 27 members and guests in attendance.

W. J. Oonk, acting secretary, read the minutes of the previous meeting which were approved as read. President Fagin reported on the action taken by the Board of Governors on the proposed change in the Society's Nominating Committee, and after a short recess, B. C. Simons introduced the speaker, Edward Malm, Chicago. Mr. Malm spoke on the subject *Engineering in Hot Water Heating Systems.*

He illustrated his talk with slides, describing hot water heating systems in low cost homes, larger residences, apartment buildings of various sizes up to 1796 units, churches, the New York World's Fair, etc., and brought out the advantages of hot water heating systems as being responsive to the weather. An interesting discussion followed and after a rising vote of thanks to Mr. Malm, the meeting adjourned.

December 2, 1941. The December meeting was held at the De-Soto Hotel, St. Louis, with President Fagin presiding, and 31 members and guests present.

Mr. Simons called upon H. O. Mehmken, member of the St. Louis

Chapter, to lead the discussion of the recently published paper A Review of Glass Transmittance Coefficients (ASHVE JOURNAL SECTION, *Heating, Piping & Air Conditioning,* November, 1941), by Houghten, Carr and Shore, from the ASHVE Research Laboratory, Pittsburgh, Pa. Mr. Mehmken analyzed the investigations into heat transmittance of glass, extracting the essence of the subject, which he delivered clearly and concisely.

After a short intermission, Chairman Simons introduced Amos C. Bartlett, Hyde Park, Mass., who spoke on the ventilation of tunnels in the Pennsylvania turnpike. He traced the history of the turnpike from the earliest Colonial days to the new 160-mile highway, the country's longest highway having separated lanes. He described the 7 tunnels, each having two 11-ft 6-in. separated lanes, and called attention to the fact that there were no grade crossings, but that the highway had 160 over-passes, 139 bridges, and that the sharpest curve has 1600-ft radius.

After considerable discussion, the members gave Mr. Bartlett a rising vote of thanks for his very able and complete presentation, followed by adjournment.

December 19, 1941. The December meeting was a joint meeting with the Air Conditioning Council of Western New York, which took the form of a gala Christmas party, attended by 69 members and guests.

The chairman of the party was Joseph Davis, assisted by D. J. Mahoney and Sherman Strouse. A feeling of good-fellowship prevailed, and a vote of thanks was extended to the chairman and his assistants.

MICHIGAN HEARS TALK ON AIR DISTRIBUTION

December 11, 1941. The December meeting was held at Huyler's L'Aiglon, Detroit, and 49 members and guests attended. Pres. J. S. Kilner called the meeting to order, and following roll call a short talkie based on the effective use of ultra-violet rays was presented.

President Kilner introduced Prof. G. L. Tuve, Case School of Applied Science, Cleveland, O., who spoke on air distribution, the proof of good air conditioning. Following an interesting discussion, with the usual questions and answers, slides were presented showing the application of bacteria destroying lamps in air conditioning systems. The meeting adjourned at 10:30 p. m., according to Secretary Old's report.

MASSACHUSETTS MEMBERS MEET

January 20, 1942. The monthly meeting was called to order at 7:30 by Vice-Pres. D. J. Edwards, with 50 members and guests present. It was announced that the February meeting would be devoted to a discussion on Fuel Conservation.

Mr. Edwards introduced T. S. Rogers, who presented some thought provoking ideas on the comfort aspect of insulation, the economic aspect and the effect on new construction during war times. After a discussion period a rising vote of thanks was extended to Mr. Rogers, followed by adjournment.

STEAM HEATING AS APPLIED TO DEFENSE TOPIC AT ONTARIO

January 5, 1942. The January meeting, attended by 65 members and guests, was held at the Royal York Hotel, and following dinner the Trans-Canada Airways presented a technicolor picture on *Skyways Across Canada.*

Pres. C. Tasker read a letter from Pres. W. L. Fleisher, in which he outlined the technical achievements of the Research Committee of the Society in relation to the war effort.

Two of the principal speakers were then introduced, J. P. Fitzsimons, who spoke on steam heating as applied to Army, Navy and Airforce developments. Following Mr. Fitzsimons' talk, H. G. Hill spoke on warm air heating as applied to airforce structures.

E. R. Gauley then spoke on the activities of the Society and especially called attention to the activities of the research work being carried on at the Society's Research Laboratory at Pittsburgh.

Following an appeal for membership by Mr. Gauley, a vote of thanks was extended to the speakers for a very interesting meeting.

REGINALD PELHAM BOLTON, HONORARY MEMBER, DIES

Reginald Pelham Bolton, Honorary Member of the Society, engineer and student of Colonial and Revolutionary history, died February 18 at his home, 638 West 158th St., New York City, after a short illness. Mr. Bolton was in his 86th year and was president and chairman of the board of the Electric Meter Corp., 116 East 19th St., New York, N. Y., and also president of R. P. Bolton Co. As a consulting engineer, Mr. Bolton designed and erected machinery for mines, shipyards, marine engines, and power plants in all parts of the world.

Since 1893 Mr. Bolton had been actively engaged in consulting engineering in New York City, served as consulting engineer to the Department of Water Supply of New York, and among the engineering projects for which he had been responsible are the plant system of R. H. Macy & Co., Inc., and the Grand Central Terminal.

Reginald Pelham Bolton

Mr. Bolton was born in London, England, on October 5, 1856, and was educated in private schools. He served his apprenticeship with Powis, James & Co., Lambeth, England, from 1872-1876 and gained his early drafting experience in Colchester and London with Davey Paxman Co.

In 1879 Mr. Bolton came to America and engaged in consulting practice. Until 1892 he spent much of his time traveling in Europe on engineering work. He designed and erected mining machinery for sulphur mines in Caltanisetta, Sicily,

and many steam plants on the island. He designed and superintended the building of marine engines for the Italian Government at Naples as well as various machine tools for their shipyards. He was also responsible for the following: the design and construction of several stern wheel steamers for Mexico and Spain; design and erection of electric light and other machinery in the Asturias; and the design and building of electric and steam hoisting machinery in England and Holland.

Mr. Bolton's association with the ASHVE dates from 1897 when he was elected a Member, so that he had an almost complete personal record of the Society's history. He served on the Board of Governors in 1901, as Second Vice-President in 1903, as First Vice-President and a member of the Board of Governors in 1905 and 1910, as President and chairman of the Board of Governors in 1911, and as a member of the Board of Governors from 1912-1913. In 1929 he was granted Life Membership by the Council of the Society.

Honorary Membership in the ASHVE was bestowed upon Mr. Bolton in 1936 with the following tribute: *"In recognition of the eminent place occupied by Reginald Pelham Bolton, as a consulting engineer, author and historian."*

Mr. Bolton was a member of many organizations including the *American Society of Civil Engineers, American Institute of Consulting Engineers, American Society of Mechanical Engineers, American Scenic and Historic Preservation Society*, Sons of the Revolution in the State of New York, and City History Club.

He was a trustee of Dyckman Institute, former secretary of the *Washington Heights Taxpayers' Association*, an honorary life member of the *New York Historical Society*, and an associate member of the *Institution of Civil Engineers*, England, from which he received the Telford Gold Medal in 1902. His clubs were Lawyers and National Arts and his hobbies were history and travel.

Mr. Bolton's interest in engineering and history was apparent in his writings, which include the following: Motive Powers, 1895; The Assault of Mt. Washington, 1901; Elevator Service, 1908; The Indians of Washington Heights, 1909; Building for Profit, 1911, 15, 22; Power for Profit, 1915; An Expensive Experiment, 1913, 17; A Municipal Experiment, 1917; New York City in Indian Possession, 1920; Indian Paths in the Great Metropolis, 1922; Washington Heights—Its Eventful Past, 1924. He was the author of a number of papers which have been presented at meetings of the Society and which appear in its TRANSACTIONS.

Surviving are his wife, Mrs. Ethelind Bolton; a daughter, who wrote historical novels under the name of Ivy Bolton and who later became Sister Mercedes, of the Protestant Episcopal Community of St. Mary, in Peekskill, N. Y.; and a son, Guy Bolton, playwright and author.

The Officers and Council of the Society have conveyed their sincere sympathy to members of the family.

Funeral services were held in New York on February 21st.

PERCY NICHOLLS DIES

Percy Nicholls, supervising engineer of the Fuels Section, U. S. Bureau of Mines, and Life Member of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, died on February 12, following an operation. Mr. Nicholls was in his 72nd year. He was born in London, June 4, 1870, graduated with honors from Leeds University with a degree of B.S. in Engineering, and came to the United States in 1897.

From 1898-1904 he was with Westinghouse Electric & Manufacturing Co., and during that time assisted in the establishment of the Westinghouse plant at Le Havre, France. In 1904-1909 he was with the Western Electric Co.; from 1909-1914 he was with the General Electric Co. and in 1915 he became director of planning and research for Franklin Manufacturing Co., Franklin, Pa., in which position he became interested in heat transmission and the use of solid fuels. From 1922-25 he was on the staff of the ASHVE Research Laboratory and then accepted appointment as supervising engineer of the Fuels Section, U. S. Bureau of Mines. Mr. Nicholls was the author of more than 50 papers and pamphlets on technical subjects and, while at the Society's Laboratory, developed the Nicholls Heat Meter.

Mr. Nicholls joined the Society in 1920 and became a Life Member in 1941. He served on many technical committees of the Society and assisted in developing the boiler testing and rating codes. At the

Percy Nicholls

time of his death he was chairman of the Society's Publication Committee. In addition to his association with the ASHVE, Mr. Nicholls was a member of the *American Society of Mechanical Engineers* and a charter member of the *Physical Society of Pittsburgh*.

The Officers and members who knew him will greatly miss his presence at Society meetings and his contributions to the technical work of the organization. All join in extending their heartfelt sympathy to his wife, Mrs. Georgia Arnold Nicholls, who survives. Funeral services for Mr. Nicholls were held in Pittsburgh on February 14.

A. B. GALLIGAN DIES IN PHILADELPHIA

Word has been received of the death of Andrew B. Galligan, manager of Galligan Brothers, heating contractors, Philadelphia, Pa., on January 5, 1942. He had been conducting his own business for the past 38 years.

Mr. Galligan was born in New Jersey in 1885 and received his early education there. He joined the ASHVE in 1920 and took an active part in its local activities. He will be missed by his many friends and colleagues in the heating and contracting field, and the Officers and Council of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS extend their sincere and heartfelt sympathy to his family who survive.

Candidates for Membership

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 28 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn, the Council, urge the members to assume their share of responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by March 16, 1942, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
BAMOND, MANUEL J., Sales & Engrg., Barber-Colman Co., Chicago, Ill. (*Reinstatement*)	A. P. Brown Tom Brown	C. E. Price L. S. Ries
BARNETT, HARRY, Chief Engr., The Powers Regulator Co., Glencoe, Ill.	E. W. Rietz A. J. Keating	C. A. Gustafson H. C. Mueller
BURKE, JOHN S., Dealer Coordinator, New Orleans Public Service, Inc., New Orleans, La.	G. E. May A. L. Dunlap	E. W. Avegno (*Non-member*) R. F. Lezeai (*Non-member*)
CALHOON, FLOYD N., Asst. Prof. Mech. Engrg., University of Michigan, Ann Arbor, Mich.	Axel Marin J. H. Walker	I. C. Crawford R. S. Hawley
CLAPPERTON, ROBERT, Asst. Engr., Canadian Industries, Ltd., Montreal, Que., Canada.	F. G. Ewens K. D. Leitch	A. J. Leitch J. P. Fitzsimons
DOHERTY, JOHN J., General Supt., Fells Plumbing & Heating, Winchester, Mass.	J. F. Tuttle H. M. Tarr	N. H. Shaw G. B. Gerrish
DRESSELL, RUSSELL E., Mech. Engr., Riggs Distler Co. Inc., Baltimore, Md. (*Advancement*)	E. H. Taze R. L. Leilich	W. C. Jones W. R. North
HERMANN, HAROLD N., Pres., Carl J. Kiefer Associates, Inc., Cincinnati, O.	G. V. Sutfin H. E. Sproull	T. D. Boyd K. A. Wright
KAMMAN, ARNOLD R., Owner, Arnold R. Kamman Co., Buffalo, N. Y. (*Advancement*)	B. C. Candee M. C. Beman	Roswell Farnham A. A. Criqui
LEINBERGER, RICHARD J. P., Engr., Pflugradt Co., Milwaukee, Wis.	A. S. Krenz J. A. Cutler	H. W. Schreiber W. A. Ouweneel
MARVIN, JOHN H., Sales Engr., John H. Marvin Co., Seattle, Wash.	C. W. May F. J. Pratt	L. L. Bysom R. E. LeRiche
MUSSER, JOHN M., Engr., (Htg. & Vtg.) U. S. Engineers, Rome, N. Y.	L. J. DuBois E. F. Weber	E. E. Carlson R. C. Smith
NORTE, WILBUR R., Mgr., Htg. Dept., Crane Co., Salt Lake City, Utah.	J. T. Young, Jr. C. J. Stermer	K. W. Watson H. B. Nielsen
OLSON, EUGENE O., Asst. Prof., Iowa State College, Ames, Iowa.	F. E. Triggs W. W. Stuart	C. W. Helstrom R. A. Norman
PARSONS, JOHN H., Vice Pres., Heating & Air Conditioning Supply, Inc., Reno, Nevada.	C. M. Mast W. E. Humes	J. E. Stevens R. C. Cushing
PETT, ALFRED W., Development Engr., The Powers Regulator Co., Glencoe, Ill.	E. W. Rietz A. J. Keating	C. A. Gustafson H. C. Mueller
PFISTER, VAN ALEN, Sales Engr., McDonnell & Miller, Chicago, Ill.	E. N. McDonnell Bruce Adams	J. E. McDonnell N. W. Swanson
PIERCE, JOSEPH D., Asst. Research Engr., Crane Co., Chicago, Ill.	M. W. McRae M. K. Fahnestock	E. P. Heckel L. N. Hunter
REX, HARLAND E., Supervisory Engr., Carrier Corp., Chicago, Ill.	Henry Lauterbach, Jr. L. L. Lewis	E. P. Heckel T. M. Cunningham
SANDFORT, JOHN F., Instructor, Iowa State College, Ames, Ia. (*Advancement*)	R. A. Norman M. P. Cleghorn	H. J. Stoever (*Non-member*) L. M. Headley (*Non-member*)
SIEMON, HERBERT B., Territory Mgr., Century Engrg. Corp., Kansas City, Mo.	E. K. Campbell O. A. Forslund	K. M. Stevens F. J. Dean, Jr.
STEGGALL, HOWARD B., Branch Mgr., United States Radiator Corp., Pittsburgh, Pa. (*Advancement*)	F. C. McIntosh P. A. Edwards	E. S. Tower J. F. McIntire
SUTFIN, GEORGE V., Sales Engr., American Blower Corp., Cincinnati, O. (*Advancement*)	H. E. Sproull R. W. Sigmund	Albert Buenger H. A. Pillen
TAYLOR, ARTHUR R., Sales Engr., Darling Bros. Ltd., Toronto, Ont., Canada.	H. J. Church H. R. Roth	H. D. Henion M. W. Shears
VON REHBERG, HUGO L., Consulting Engr., Braman Dow & Co., Boston, Mass.	J. F. Tuttle J. W. Brinton	G. B. Gerrish E. L. Blair
WALLICH, A. C., Sales Engr., Cardox Corp., Chicago, Ill. (*Reinstatement*)	E. E. Dubry G. D. Winans	S. S. Sanford G. H. Tuttle

CANDIDATES

WEBSTER, WILLIAM H. JR., Sales, Allied Heating Products Co., Norfolk, Va. (*Reinstatement*)

WHEELER, CHARLES W., Sales Engr., The Ric-wiL Co., Cleveland, O. (*Reinstatement*)

REFERENCES

Proposers	*Seconders*
H. S. Nowitsky	E. B. Tazewell
W. J. Powell	Graham Hurst
Arthur Nass	F. C. McIntosh
Paul Edwards	C. Gottwald

Candidates Elected

In the past issues of the JOURNAL of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

MEMBERS

BYERS, ROBERT L., Engr., John Paul Jones, Cary & Millar, Cleveland, O.

MCKAY, ALBERT W., Secy-Treas., Conditioned Air, Inc., Macon, Ga.

SOCKWELL, CHARLES SR., Sr. Partner, Sockwell Co., Atlanta, Ga.

WILSON, JAMES, Service Engr., Darling Bros. Ltd., Montreal, Que., Canada.

ASSOCIATES

MCKERNAN, GORDON S., Secy.-Treas., Reg. H. Steen Ltd., Toronto, Ont., Canada.

MELTON, HOWARD E., Mgr., Howard E. Melton, Inc., Oklahoma City, Okla.

O'CONNELL, THOMAS D'ARCY, Pres. & Mgr., Thomas O'Connell Ltd., Montreal, Que., Canada.

SELDEN, KARL W., JR., Dist. Repr., Minneapolis-Honeywell Regulator Co., Charlotte, N. C.

SHORT, WILLIAM W., Field Sales Engr., Anemostat Corporation of America, New York, N. Y.

SOCKWELL, CHARLES JR., Partner, Sockwell Co., Atlanta, Ga.

SOCKWELL, TYRUS R., Partner, Sockwell Co., Atlanta, Ga.

Officers, Council and Committees

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

51 Madison Ave., New York, N. Y.

OFFICERS

President.....E. O. EASTWOOD
First Vice-President.....M. F. BLANKIN
Second Vice-President.....S. H. DOWNS
Treasurer.....E. K. CAMPBELL
Secretary.....A. V. HUTCHINSON
Technical Secretary.....JOHN JAMES

COUNCIL

E. O. EASTWOOD, *Chairman* M. F. BLANKIN, *Vice-Chairman*
F. C. MCINTOSH, *Ex-Officio*

Three Years: L. G. MILLER, A. J. OFFNER, A. E. STACEY, JR., B. M. WOODS.

Two Years: A. P. KRATZ, W. A. RUSSELL, L. P. SAUNDERS, C. TASKER.

One Year: J. F. COLLINS, JR., W. L. FLEISHER, E. N. MCDONNELL, T. H. URDAHL, C.-E. A. WINSLOW.

COUNCIL COMMITTEES

Executive—W. L. Fleisher, *Chairman*, A. J. Offner, A. E. Stacey Jr.
Finance—E. N. McDonnell, *Chairman*, J. F. Collins, Jr., C.-E. A. Winslow.
Membership—W. A. Russell, *Chairman*, M. F. Blankin, B. M. Woods.
Standards—S. H. Downs, *Chairman*, L. G. Miller, C. Tasker.
Meetings—A. P. Kratz, *Chairman*, L. P. Saunders, T. H. Urdahl.

ADVISORY COUNCIL

W. L. Fleisher, *Chairman;* Homer Addams, D. S. Boyden, W. H. Carrier, S. E. Dibble, W. H. Driscoll, F. E. Giesecke, H. P. Gant, E. Holt Gurney, John F. Hale, L. A. Harding, H. M. Hart, C. V. Haynes, E. Vernon Hill, John Howatt, W. T. Jones, D. D. Kimball, G. L. Larson, S. R. Lewis, Thornton Lewis, J. I. Lyle, J. F. McIntire, F. B. Rowley and A. C. Willard.

SPECIAL COMMITTEES

Admission and Advancement—Earle W. Gray, *Chairman (one year);* E. P. Heckel (*two years*), T. T. Tucker (*three years*).
Chapter Relations—J. F. Collins, Jr., *Chairman;* Joseph Wheeler, Jr., Lincoln Bouillon.
Guide Publication—A. J. Offner, *Chairman*, P. D. Close, S. Konzo, C. S. Leopold, G. L. Tuve.
Constitution and By-Laws—Albert Buenger, *Chairman*, L. T. Avery, R. H. Carpenter.
F. Paul Anderson Award—M. F. Blankin, *Chairman*, W. H. Carrier, J. D. Kroeker, J. F. McIntire, F. B. Rowley.

NOMINATING COMMITTEE 1942

Chapter	*Representative*	*Alternate*
Atlanta	T. T. Tucker	A. H. Koch
Cincinnati	C. E. Hust	Albert Buenger
Connecticut	L. E. Seeley	Stanley Hart
Delta	L. V. Cressy	J. S. Adair
Golden Gate	C. E. Bentley	
Illinois	M. W. Bishop	E. M. Mittendorff
Iowa	Perry LaRue	F. E. Triggs
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